REPORT OF

Thirty-Fifth Annual

DATE GROWERS' INSTITUTE

April 26, 1958

HELD IN

COACHELLA VALLEY

CALIFORNIA

Volume 35

Published by the

DATE GROWERS' INSTITUTE

Coachella Valley, California

October, 1958

The Date Growers' Institute is the official educational instrument of the date industry. Its goal is the dissemination of information on date growing, handling and marketing. This is its thirty-fifth year. Proceedings of each Institute have been published, and may be purchased in complete sets, or by separate copies. A full Index will be mailed on request. Direct all Inquiries to

MRS. T. R. BROWN
Secretary-Treasurer
Route 2, Box 81
Thermal, California

THIRTY-FIFTH ANNUAL
DATE GROWERS' INSTITUTE

HELD IN

COACHELLA VALLEY

APRIL 26, 1958

VOLUME 35

CHAIRMAN MORNING SESSION
G. L. Rygg
U. S. Department of Agriculture
Pomona

CHAIRMAN AFTERNOON SESSION
Mrs. Edna Cast
Garden of the Setting Sun
Mecca

INFLUENCE OF HANDLING PROCEDURES AND STORAGE AND TRANSIT TEMPERATURES ON IMPROVING AND MAINTAINING QUALITY OF DATES

By G. L. Rygg

Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture, Pomona, California

The quality of dates is largely determined by the conditions to which they are exposed between the time they ripen on the palm and the time they reach the consumer. At their best, dates are a delicious confection, but frequently they are of indifferent quality at the end of the marketing channel. Since the quantity of dates purchased by consumers is undoubtedly influenced by the quality, date growers and packers are directly affected by the condition in which their product is offered to the public.

MEASURES OF QUALITY

Flavor, texture and color. The measures of quality available for use on dates are not entirely satisfactory. Flavor and texture are two of the most important qualities. In varieties normally characterized by a moderately light color, the degree of darkness, along with general appearance and softness, is probably the best nondestructive indicator of quality. However, there is at present no satisfactory way to measure and express the depth of color quantitatively. Likewise, no methods are available for expressing flavor and texture quantitatively.

Sugar content. Total sugar content is of little value in describing quality. All dates acceptable in other respects are certain to have an adequate sugar content. In Deglet Noor dates the degree of inversion is related to quality, but in a manner that does not permit its use in the description of quality. The proportion of sucrose is high in both dry-textured and high quality naturals, but low in moist dates that have been stored at high temperatures. Hydrolysis of sucrose proceeds during processing and in storage at a rate influenced by the moisture content of the dates and by the temperature. The degree of inversion of surcrose is probably less significant in influencing quality than the extent of some of the other hydrolytic reactions promoted by the same conditions of temperature and moisture that promote sucrose hydrolysis, but these hydrolytic reactions are more difficult to measure. All or nearly all the sugar in soft-type dates is in the invert form when the dates are fully ripe.

pH. The pH of date flesh is often associated with quality (11), but sufficient data are not available to permit use of this measurement in the description of quality or grade standards. Deglet Noor dates that have a pH value of 6.0 or higher at harvest are almost certain to have excellent flavor and texture. Mite-injured dates constitute an exception, for, although the pH may be well above 6.0, the flesh is hard and fails to respond to softening treatments. Dates with a pH value of 5.5 or lower at harvest are likely to have a dry texture. Interpretation of the significance of high acidity (low pH) is confused by the fact that high acidity may be inherent in the date at harvest as discussed previously, or it may be the result of age or too long exposure to high temperature after harvest.

Odor. Odor is useful as an indicator of quality only in extreme cases. The fragrance of good fresh dates is short-lived even under the best available storage conditions, and its absence does not necessarily indicate excessive loss of quality. On the other hand, objectionable odors usually develop only as a result of attack by microorganisms such as yeasts or molds unless the dates have been kept too long or held at too high temperature.

METHODS OF IMPROVING QUALITY

The quality of dates may be improved by curing, hydration or processing (increasing the moisture content by infiltration). Low pressure steam treatment also has shown some promise.

Curing. In curing of dates the tissue breakdown that began with ripening is carried through to the desired degree and part of the moisture is removed. The amount of curing needed is determined by the initial condition of the fruit and the objective of the operator. Soft-type varieties are commonly cured at temperatures of 95° to 115° F., but the Deglet Noor variety is usually cured at a temperature that does not exceed 95° to 100°. Flavor is improved by curing at lower temperatures but more time is required.

Hydration and processing. Dates that are moderately dry and hard may usually be improved by steam hydration or by processing (vacuum infiltration). These dry dates often have a low pH value, and the lower the pH the more difficult they are to soften by either steam hydration or processing. The response of the drier, more acid dates to softening treatment is improved by infiltration with an alkaline solution at pH 8.0 to 8.5. The degree of alkalinity needed is related to the acidity of the dates to be softened. Ammonium sulfite at a concentration of 1,000 to 2,000 p.p.m. sulfite is the most effective reagent that has been used. The ammonium in the ammonium sulfite reduces the acidity and the sulfite prevents undue darkening. Sodium bisulfite is an effective softening aid but a darker colored product is formed. Ammonium hydroxide and carbonate also produce dark dates.

Steam pressure. The texture and appearance of dry Deglet Noor dates were improved experimentally by heating briefly at a low steam pressure in a pressure cooker, but more work must be done before recommendations can be made. Less moisture was added by this method than by steam hydration or processing. The treatment melted the wax on the surface of the dates and produced a high gloss. Very hard dates could not be softened by any method without damaging the flavor.

METHODS OF MAINTAINING QUALITY

The retention of quality in dates can be improved by drying, using a volatile fungicide, pasteurization, packing in vacuum or in an inert gas, and by using low temperatures in storage and transit. Antioxidants have not been helpful.

Effect of moisture content. The rate of deterioration is influenced appreciably by moisture content. On the basis of color, flavor and pH, Deglet Noor dates stored at 75° F. were of approximately equal quality after 1 month at 24 percent moisture, 2 months at 22 percent moisture and 6 months at 18 percent moisture. Likewise, dates stored at 40° were about equally good after 3 months at 28 percent moisture and 6 months at 26 percent moisture (14). Deglet Noor dates that do not have more than 23 to 24 percent moisture retain good quality for 1 year at 32°. For

maintaining good quality and uniform color, however, dates with higher moisture contents should be stored at 0° if they are to be held as long as a year. The preservation of quality cannot be accomplished in commercial practice by lowering moisture content alone because the texture, especially that of the Deglet Noor variety, becomes too hard, and even very dry dates deteriorate slowly at ordinary temperatures and are subject to insect infestation.

Moisture contents of about 24 to 30 percent favor the rapid development of sugar spots in soft-type dates when stored at 32° F. Little spotting develops at moisture contents below 22 percent and above 33 percent. Unfortunately, the range of moisture associated with the most desirable texture is included in the range at which sugar spotting is most serious. Sugar spotting is controlled more effectively by choice of a proper storage temperature rather than by adjusting the moisture content.

Volatile fungicide. The control of mold and fermentation is reasonably well accomplished by using a proprietary mixture consisting of 15 percent ethylene oxide and 85 percent methyl formate at the rate of 1 milliliter per pound of dates. Some of the occasional failures observed in commercial packages may be attributed to improper sealing of the film overwrap or to failure of the applicator to function properly. However, both mold and fermentation appear to be more difficult to control as the moisture content of the dates increases.

Pasteurization. As early as 1917 Forbes (6) reported the use of pasteurization as a method for reducing deterioration of dates. He held the dates for 2 to 4 hours at 149° F. and noted that the treatment killed all forms of insect life. A shorter heating period was adopted later to reduce the adverse effects on color and flavor. More recent recommendations for pasteurization vary from 30 minutes (8) to 60 minutes (5) at 151°. Experiments have shown, however, that 1 hour at 176° is inadequate for very moist dates, that 4 hours at 150° failed to kill all the fungi and bacteria (7), and that many yeast organisms survived 30 minutes at 165°. Pasteurization has been used extensively in Arizona, but only to a limited extent in California.

Vacuum or inert gas. The storage life of dates can be extended by canning in a vacuum or in an inert gas, such as nitrogen, and applying a suitable pasteurization treatment. This has been demonstrated by Nielsen et al (9). Observations on commercially vacuum-canned dates indicate that they may have a shelf life 2 to 3 times as long at room temperature as those exposed to air. The prolonged shelf life could be advantageous, but it is difficult to prevent anyone from allowing the dates to remain at room temperature too long (12). If canned dates were held under refrigeration until they were displayed on the store shelves, there could be considerable benefit from the use of this method of packaging, but the high cost is likely to prevent its adoption for extensive use in the near future.

Experiments with dates packaged in nitrogen in Saran bags gave varying results. Complete exclusion of oxygen for an extended period is impossible because all presently available films have at least a small gas permeability. In addition, a completely airtight seal with Saran is difficult to obtain consistently, and results indicate that this film lacks uniformity and that oxygen sometimes diffuses through it rather rapidly. However, the results showed that color and flavor were retained better and the gain in acidity was retarded when the dates were held in nitrogen. Similar observations were made on dates held in vacuum.

Packaging dates in vacuum in film containers is impractical because of the unattractive appearance of the package. It also is likely to fail because the film has a slight permeability to oxygen.

Refrigeration. Refrigeration has been used as an aid in maintaining date quality since the early days of the American date industry. Workers at the Arizona Agricultural Experiment Station (6) reported that in 1916 their experiments had produced some favorable results and some failures. Spoilage occurred in the more moist dates. They reported that prior to this time a dealer in San Francisco held fresh dates satisfactorily in dry cold storage several months and thereby extended the marketing period. In 1926 Swingle (18) reported that discouraging results were obtained in 1920, but that these were followed by more favorable results in 1924. Since that time continued progress has been made in learning the conditions required for the storage of dates and in the commercial application of this information (1, 2, 3, 4, 7, 10, 13, 14, 15, 16).

As improved methods of preparing and storing dates were developed, the date marketing period was extended to encompass the entire year. The use of low-temperature storage was an indispensable factor in this extension of the marketing period.

On the basis of color and flavor, the maximum storage life of Deglet Noor dates with moisture percentage in the middle 20's was about 1 month at 80° F., 3 months at 60°, 8 months at 40°, and 1 year at 32° (13). These maximum storage periods are for minimum readily acceptable quality and are too long for the retention of high quality.

Several handlers are currently consigning to freezer storage (0° F.) dates packed after the holidays because of the reduced sales volume during the latter part of the marketing season. There are two principal reasons for adopting this lower temperature. One is the uncertainty in some instances that a temperature of 32° is maintained consistently when it has been specified, and the other is the creation of increased confidence in the mind of the buyer that the product is sure to have good quality. In addition to these reasons, freezer storage destroys all forms of insect life that might have escaped previous treatment (17) and reduces the variability in color resulting from differences in moisture content.

Dates should be marketed as soon as possible after they are removed from cold storage; otherwise the benefits of cold storage are gradually lost. Dates stored 1 year at 32° or 0° F. were acceptable after 1 month at 70°, but after 2 months they had darkened and lost flavor to a noticeable extent. After 3 months at 70° most of the benefits of the previous cold storage were lost.

To assure a consistently reliable product, one should store soft-type dates at 0° F. as soon as possible after harvest and maintain this temperature during as much of the marketing period as possible. Sugar spots develop within a few months at 32°, whereas at 0° only a few small ones form in 1 year. Soft-type dates remain attractive after 2 years at —10°, but lose much of their flavor. The loss of flavor is more pronounced in moist dates than in dry ones.

Varieties of soft-type dates differ in their tendency to form sugar spots. For example, at the same moisture content and temperature, Barhee dates sometimes spot as much in 4 months as Khadrawy and Medjool dates do in 9 months. Halawy dates are similar to Barhee dates in this respect.

Precooling experiments with dates in cartons and in individual trays were undertaken in the storage facilities of the California Date Growers' Association, Indio, California, to learn the rate of cooling. The cartons contained 24 film-overwrapped trays, each of which contained 12 ounces of dates. Each pallet was loaded with 3 layers of 5 cartons each, or a total of 15 cartons. Thermocouples were placed near the center of the pallet loads to obtain the temperature of the dates that cooled slowest. In the tests with individual trays, thermo-

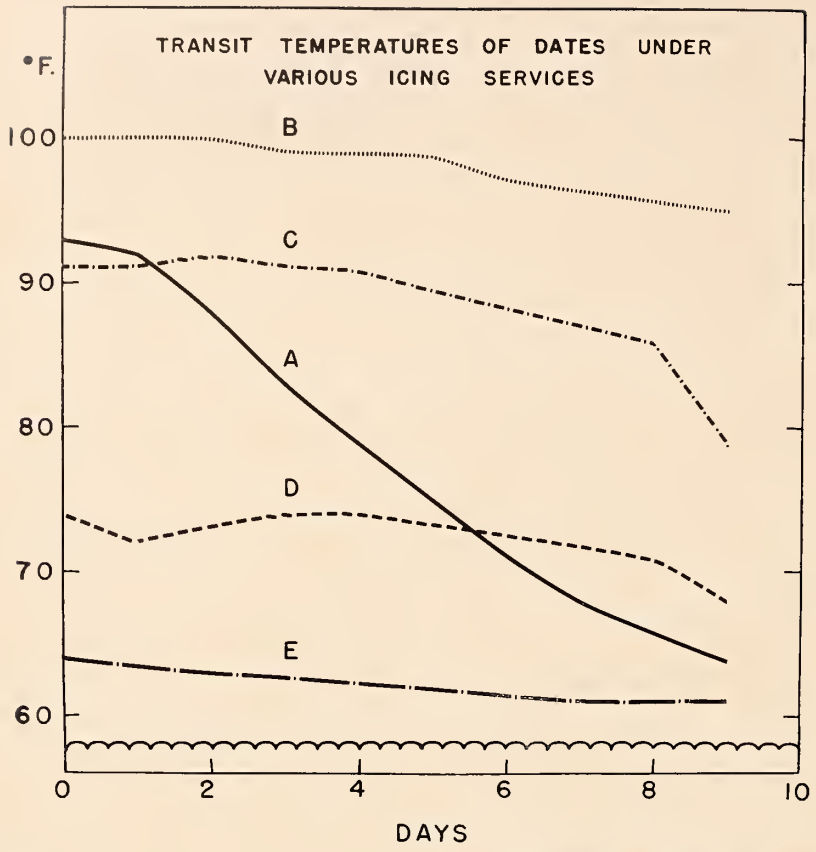

Figure 1. *Transit temperatures of dates under various icing services while enroute from California to New York, N. Y.*

A. Loaded Sept. 5, 1952. Full bunkers; standard refrigeration. No fans and no flues. Load consisted of 2,041 flats.

B. Loaded Sept. 30, 1952. Full bunkers; initially iced only. Car was equipped with fans and flues. Load consisted of 2,000 cartons and 400 flats.

C. Loaded Oct. 7, 1952. Full bunkers; initially iced only. Car was equipped with fans and flues. Load consisted of mixed flats and cartons. The upper half of the load was removed at Pittsburgh, Pa.

D. Loaded Sept. 11, 1953. Half-stage; standard refrigeration; precooled and preiced. No fans and no flues. Load consisted of 2,407 cartons.

E. Loaded Sept. 16, 1952. Full bunker; initially iced. Car was equipped with fans and flues. Load consisted of 2,541 cartons.

couples were placed in dates near the center of the film-overwrapped trays. The cartons on pallets and the individual trays were cooled by an air blast at 33° to 34.5° F.

Experimental hydrocooling consisted of immersing 12-ounce overwrapped trays in ice water maintained at 32° F. Thermocouples were inserted into dates near the center of the trays immediately after the trays were removed from the water.

The dates in the center of the palletized cartons cooled 60 degrees (from 106° to 46° F.) in 23 hours. A like amount of cooling in the exposed trays required only 2 hours. The individual trays cooled 44 degrees during the first hour compared with 1.2 degrees in the cartons. Hydrocooling lowered the temperature about 4 times as rapidly as air cooling of individual trays, but moisture on the packages was objectionable and faulty sealing permitted entry of water into a few of the packages.

Attempts to cool dates by vacuum have been unsuccessful. At a pressure of 1 millimeter of mercury the temperature was lowered from 68° to 46° F. in 3 hours in one experiment and from 77° to 58° in 1½ hours in another. The dates lost 6 to 7 percent in weight and became puffy and unattractive looking.

Date temperatures during transit in refrigerator cars were measured with recording thermometers[1]. In 12 test shipments made to New York, the services varied from no ice to full-bunker standard refrigeration (reicing at all regular icing stations). Loading temperatures were 52° to 100° F. Some cars were equipped with circulating fans and wall flues; others had neither. The dates were packed in wooden flats or in fiberboard cartons. The flats contained 15 pounds of bulk dates and the cartons contained 24 8-ounce film-overwrapped packages.

Representative temperatures at the middle layer quarterlength centerline position are shown in figure 1. In fan-equipped cars the temperature at this position is generally reduced somewhat less rapidly than in top or bottom layers where surface exposure to air is greater. In non-fan cars middle-layer temperature reduction is usually intermediate between the slow cooling in top layers and rapid cooling in bottom layers, but because of the tight load in date cars, even the top layers cool more rapidly than the middle layers.

The amount of cooling enroute was from none (not shown in fig. 1) to 29 degrees (car A, fig. 1). The cooling in 8 of the loads was 10 degrees or less.

The poor cooling can be attributed to lack of circulation of air through the load. The amount of ice and the presence or absence of fans had little or no effect. The greatest amount of cooling was obtained in car A under standard refrigeration with full bunkers. This car was not equipped with fans. The load, which consisted of dates packed in 15-pound wooden flats, permitted a fair amount of vertical air movement. The load in another car (not show in fig. 1), refrigerated in the same manner but loaded with dates in cartons, was cooled only 4 degrees F. Although this car was equipped with air-circulating fans, almost no heat was removed from the load. Practically no air circulation could take place within the loads of cars containing dates in cartons. The dates were enclosed in sealed film packages and these were enclosed in non-ventilated fiberboard cartons. The cartons were lock-loaded with the layers alternating, thus effectively preventing vertical air movement. Tight stowing also prevented lateral air movement. Air circulation was prevented additionally by a layer of fiberboard placed over the false floors of the cars to protect the underside of the bottom layer of cartons.

In cars destined for unloading at two different cities the portion consigned to the more distance city was placed on the bottom of the load

[1]*Acknowledgements are due California Date Growers' Association and Associated Date Growers and Packers of Indio, California, for providing test cars; and J. Kaufman, J. M. Lutz, and W. A. Radspinner, at that time at the Market Pathology Laboratory, Agricultural Marketing Service, New York, N. Y., for receiving and reporting on these tests.*

and a layer of wrapping paper was used to separate it from the upper portion that would be unloaded first. This constituted still another barrier to air circulation. Car C is an example of this type of load. A sharp drop in temperature occurred after the upper portion of the load and the layer of paper were removed at Pittsburgh.

In view of the small amount of cooling in transit, especially in loads of dates in cartons, it is doubtful whether the refrigeration service is worthwhile. A more effective and less costly method of maintaining date quality is to cool the dates before they are loaded into the car. Since dates produce very little heat of respiration, only enough car refrigeration is then required to remove heat entering the car from the outside.

Antioxidants. Attempts to improve retention of color and flavor in dates by treating with various antioxidants have failed. The probable reason for the failure is that the antioxidants were of necessity applied to the skin of the dates, whereas the darkening occurs in the flesh. Antioxidants used included formulation of butylated hydroxyanisole, propyl gallate, and butylated hydroxytoluene.

SUMMARY

Measures of quality and methods of improving and retaining quality have been described and discussed.

Flavor and texture are two of the best indicators of quality. Color is a useful nondestructive indicator in varieties normally of a light color. pH is associated with quality to some extent. Sugar content and odor are not especially useful in describing quality.

Quality of dates may be improved by curing, hydrating, processing, and possibly by subjecting to a low steam pressure. Dry-textured dates moderately high in acid may be softened better by infiltrating with a dilute solution of ammonium sulfite. None of these methods produces a satisfactory product from dates that are too dry and hard.

Retention of quality may be improved by lowering the moisture content, using a volatile fungicide, pasteurizing, storing in vacuum or in an inert gas, and by refrigerating.

Differences of a few percent in moisture content produce large differences in rate of deterioration.

A volatile fungicide containing ethylene oxide is helpful in preventing mold and fermentation. Pasteurization also reduces date spoilage. Both methods become less effective as the moisture content of the dates increases.

Storage in vacuum or in an inert gas is helpful in preserving color and flavor, but neither of these is a substitute for refrigeration.

Low temperature is helpful in improving the retention of good quality. The Deglet Noor variety should be held at 32° or 0° F., depending upon the moisture content and the length of storage. Soft-type dates should be stored at 0° to avoid sugar spotting. To retain the benefits of refrigerated storage, dates should be marketed as soon as possible after removal.

Low transit temperatures can be obtained best by cooling the dates before they are loaded into cars.

Antioxidants have not aided in the preservation of good color or flavor.

REFERENCES

1. *Albert, D. W., and R. H. Hilgeman.* 1935. *Date growing in Arizona. Ariz. Agr. Exp. Sta. Bul.* 149. *pp.* 231-286.
2. *Barger, W. R.* 1933. *Experiments with California dates in storage. Date Growers' Inst. Ann. Rept.* 10: 3-5.
3. *Barger, W. R.* 1934. *The effect of humidity and containers on dates. Date Growers' Inst. Ann. Rept.* 11: 14-18.
4. *Barger, W. R., and A. F. Silvers.* 1927. *Experiments on storage of Deglet Noor dates. Date growers' Inst. Ann. Rept.* 4: 9-10.
5. *Clague, J. A., and C. R. Fellers.* 1933. *Time, temperature and humidity relationships in the pasteurization of dates. Archiv. f. Mikrobiol. Bd.* 4, 5 419-426.
6. *Forbes, R. H.* 1917. *The date orchard. In Ariz. Agr. Exp. Sta. Ann. Rept.* 28: 442-451.
7. *Hilgeman, R. H., and J. G. Smith.* 1938. *Maturation and storage studies with soft varieties of dates. Date Growers' Inst. Ann. Rept.* 15: 14-17.
8. *Hyde, Jay. Processing Arizona dates.* 1948. 20 *pp., illus. Arizona Date Institute, Phoenix, Ariz.*
9. *Nielsen, B. W., R. J. McColloch, and E. A. Beavens.* 1950. *Processing and packaging dates. I. A new method of canning and pasteurizing Deglet Noor dates. Food Technol.* 4: 232-237.
10. *Rygg, G. L.* 1942. *Factors affecting sugar spotting in dates. Date Growers' Inst. Ann. Rept.* 19: 10-12.
11. *Rygg, G. L.* 1948. *Acidity in relation to quality in the date fruit. Date Growers' Inst. Ann. Rept.* 25: 32-33.
12. *Rygg, G. L.* 1954. *Quality of dates in some American markets. Date Growers' Inst. Ann. Rept.* 31: 20-26.
13. *Rygg, G. L.* 1956. *Effect of temperature and moisture content on the rate of deterioration in Deglet Noor dates. Date Growers' Inst. Ann. Rept.* 33: 8-11.
14. *Rygg, G. L.* 1957. *Relation of moisture content on rate of darkening in Deglet Noor dates. Date Growers' Inst. Ann. Rept.* 34: 12-13.
15. *Sharples, G. C.* 1953. *A study of spoilage and the microorganism population of soft dates. Date Growers' Inst. Ann. Rept.* 30: 5-8.
16. *Sievers, A. F., and W. R. Barger.* 1930. *Experiments on the processing and storing of Deglet Noor dates in California. USDA Tech. Bul.* 193. 24 *pp.*
17. *Stickney, Fenner S., Dwight F. Barnes, and Perez Simmons.* 1950. *Date palm insects in the United States. USDA Circ.* 846. 57 *pp.*
18. *Swingle, Leonhardt.* 1926. *Cold Storage of dates. Date Growers' Inst. Ann. Rept.* 3: 3-6.

DR. RYGG RECEIVES SUPERIOR SERVICE AWARDS

Dr. G. L. Rygg was born in North Dakota and graduated from the North Dakota Agricultural College. On a research fellowship he received his Masters Degree at Oregon State College, and later earned a Ph.d. at the University of Minnesota. In 1930 he entered the U.S.-D.A. employment in Corvallis, Oregon. He has done research work in dates in Indio, and continued the work in date storage and handling while at Pomona. At present Dr. Rygg is Supervisory Plant Physiologist in charge of the Pomona Laboratory of Quality Maintenance and Improvement Section of the Agricultural Marketing Service. Work at this laboratory includes storage and transportation problems on citrus fruits, nut meats and several vegetables, in addition to dates.

The Superior Service award was presented to Dr. Rygg at a public ceremony in Washington, D. C., May 27, 1958. Awards were presented to a group of U.S.-D.A. employees by the Secretary of Agriculture, Ezra Taft Benson.

NEW ROOT DEVELOPMENT ON TRUNKS OF DATE PALMS BURIED IN SOIL

By Roy W. Nixon

U. S. Date Field Station, Indio, California

Many difficulties arise from the increasing height of old date palms. Because height increases the cost of all cultural operations some owners of old date palms have already decided that under present economic conditions it does not pay to fruit them. From time to time the old palms blow down or begin to lean precariously and have to be supported by props or guy wires at considerable expense. Subdivisions in Coachella Valley, however, are finding old date palms useful as ornamentals and many are being transplanted for that purpose. Some are being placed in border rows around fields used for other crops. Occasionally some of these transplants are fruited. In transplanting old date palms it is desirable to set them deeper than they originally stood, not only to reduce the cost of subsequent operations in the crown but also to provide better anchorage and stability for the trunk. Therefore it seems desirable to record information concerning the extent to which new roots may be expected to develop on the trunks of date palms buried in soil.

Dr. Walter T. Swingle, under whose direction date investigations by the U. S. Department of Agriculture were begun and conducted for the first three decades in Coachella Valley, anticipated difficulties with old date palms because of their height and began trials of two different methods of lowering them: (1) replanting at a lower depth and (2) laying the trunk down horizontally and covering it with soil. Dr. Swingle had left the U. S. Date Field Station and was retired before the final outcome of the two tests was determined, but the writer took photographs, made notes and will report the results.

REPLANTING AT A LOWER DEPTH

In the summer of 1923 a palm of the Kenta variety (a dry date from Tunisia), about 13 years old and as many feet high to the bud, was dug up and replanted 10 feet deeper in another location so that only the top 3 feet of the trunk was above ground. Most of the leaves were removed except a few around the bud which were reduced in length and tied up as is done in planting offshoots. An examination of the trunk in 1928 revealed no roots above a depth of 9 feet. On February 6, 1941, numerous roots were found emerging from the trunk in the first 2 feet below the soil surface; no examination below this depth was made at that time. On May 9, 1947, after 24 years, the Kenta palm was removed after a 10-foot pit had been dug around it so that the condition of the buried portion of the trunk could be seen. For the first 2 feet below the soil surface there were many roots emerging from the trunk (Figure 1). These roots were nearly all light straw brown in color and smooth on the surface. From 2 to 6 feet below the surface there were almost no roots on the trunk. Below 6 feet there were many roots, most of them dull gray or brown, occasionally almost black, and with a rough surface. The roots in the upper part of this lower zone had apparently developed after the palm was examined in 1928, and those near the soil surface at a still later date.

LAYING THE TRUNK DOWN HORIZONTALLY AND COVERING IT WITH SOIL

On June 4, 1924, a palm of the Thoory variety, 17 years old and about 14 feet high, was pulled down to the soil surface. To accomplish this it was necessary to excavate and cut some roots on opposite sides in line with the direction in which the palm was lowered; no more than necessary were cut on these two sides and none was cut on the other sides. Slow lowering was accomplished with a bipod of 4x4 timbers and a block and tackle. The trunk was covered with soil up to the green leaves below the crown. By 1930 the terminal bud had turned upward and made sufficient vertical growth to permit the horizontal portion of the trunk to be lowered still farther by digging a trench beneath it, about 3 feet deep, and placing heavy weights (blocks of cement) on the trunk to force it down. No root growth was noted on the trunk above the base at this time.

On March 1, 1941, the buried portion of the trunk was excavated and examined for root formation.

Figure 1. *Appearance in* 1947 *of the underground portion of the trunk of a date palm which in* 1923 *was replanted* 10 *feet lower than it originally stood. New roots above, old roots below.*

By that time a small offshoot left at the base had developed into a palm 15 feet high without visible connection with the original crown, rising 10 feet above the soil surface some 10 feet away. Many roots appeared to be emerging from the trunk, but upon cutting away the old rotting leaf bases (some of which still retained apparently live tissue an inch or more from the trunk proper) it was found that most of these roots were not connected with the trunk in that region. Instead, roots originating elsewhere had grown into dead tissue between the leaf bases and had emerged from another nearby point, giving the appearance of roots coming from the trunk. A few roots, however, had developed along the trunk. The root farthest from the base was 10 feet, 9 inches distant, at a point where a cut had been made into the trunk tissue just below the upward turn.

DISCUSSION

Both methods of lowering palms, replanting at a lower depth and laying the palm down horizontally and covering it with soil, finally resulted in the formation of new roots on the trunk 9 to 10 feet from the base. These distances represent the highest points covered by soil; therefore it seems likely that if taller palms had been used, and if more of the trunk had been covered with soil, rooting would have occurred at an even greater distance from the base.

New roots were slow in forming above the old ones. None was found after 5 or 6 years, but examinations were not made at intervals frequent enough to determine just how soon the new roots did form. After 18 years the palm reset at a lower depth had a well-developed root system in the top 2 feet of soil. The palm that had been laid down had relatively few roots after 17 years, but this is not surprising since a large proportion of its original root system continued to function after the trunk was lowered.

It is well known that the adventitious roots that form on the trunk just above the soil surface at heights increasing with age, function the same as those below the surface if soil is made available for their development. Growers frequently mound the soil around the base of old palms so that these higher roots will anchor the trunk more firmly, a practice that has long been followed in many parts of the Old World. These two tests demonstrate, however, that under favorable conditions the formation and development of adventitious roots may be induced at a point much higher on the trunk than normally occurs in the field. This has been mentioned in the literature but few data upon which to base cultural practice have been available.

Pliny (4) reported that in Assyria the trunk of a date palm was sometimes laid level and covered over with moist soil, and then new roots formed, but apparently in this case the practice was for the promotion of offshoot production as the operation was said to produce "a number of shrubs and never a tree." Schweinfurth (5) found that in Egypt rare and valuable old palms were sometimes induced to root just below the crown by attaching to the trunk at that point a sort of basket filled with a manure-soil mixture which if kept moist by frequent watering would induce rooting in 8 to 10 months; whereupon the trunk could be severed just below the new roots and the top planted as a new palm. The University of Arizona (1) reported the formation of roots just below the crown of a 30 foot palm after this portion of the trunk had been enclosed for some time in a box of moist soil supported by scaffolding. In Oman, Dowson (2) described a method of replanting a date palm in the same position at a lower depth by digging a pit about 6 feet deep below the palm before severing all roots to permit it to drop. The method was said to be used not to lower the crown, but to improve the bearing of old palms, possibly by bringing the roots nearer to a water table or by improving moisture conditions in the root zone by breaking up a hard pan.

An unusual instance of root formation on the trunks of date palms was recently reported by Pereau-Leroy (3) from southern Libya where in one locality sand dunes gradually moving into date gardens resulted in the formation of roots

all up the covered trunk. After a period of years the slow-moving dunes finally left the date gardens, exposing the roots that had formed high up on the trunks.

CONCLUSIONS

The results of the two tests described demonstrate that tall palms may be transplanted and safely set considerably lower than they were in the original plantings. But it is apparent that for some time after transplanting, the growth of the palm depends upon the functioning of the old root zone. It seems important, therefore, that the base of the trunk be in soil that can support growth and that it be supplied with adequate moisture. Since soil 5 to 10 feet below the surface is not likely to be as favorable for root growth as that nearer the surface, it appears wise to place in the bottom of the hole enough top soil to provide favorable conditions around the old root zone, and to leave around the trunk at the soil surface a basin deep enough to hold sufficient water to reach the root zone. In time the development of new roots can be expected near the soil surface, but the behavior of the two palms described indicate that it may be a good many years before there are enough roots to replace those at the lower depth. Aside from other considerations, the high cost of transplanting old date palms will in most cases prevent their use except for ornamental purposes, quick shade, or special border plantings.

LITERATURE CITED

1. *Anonymous.* 1932. *Date studies. Forty-third Annual Report, Univ. of Ariz., Coll. of Agri., Agr. Expt. Sta. pp.* 94-95.
2. *Dowson, V. H. W.* 1936. *Differences in date culture in different places. Date Growers' Inst. Rept.* 13: 8-11.
3. *Pereau-Leroy, P.* 1952. *Note sur le palmier dattier au Fezzan. Fruits d'Outre Mer* 7: 129-131, *illus.*
4. *Plinius Secundus, Gaius* (61-113 *A.D.*) 1855-1890. *The natural history of Pliny.* 6 *vols. English transl. by John Bostock and H. T. Riley. H. G. Bohn, London. Vol.* 3, *Book XIII, Chap.* 8.
5. *Schweinfurth, Georg.* 1901. *Ueber die kultur der dattelpalme. Gartenflora* 50: 543-544.

A METHOD OF DUSTING TALL DATE PALMS

By E. J. Codekas

We have had considerable difficulty in the early dusting of our tall date palms in the Sun Gold property west of Indio. The fruit bunches on these palms hang 40 feet in the air and unless the day is dead calm it is difficult to get complete coverage of the bunches by using a power duster. The weather in this area during May is usually breezy day and night and we have had a power duster set up and waiting for intervals of up to two weeks without getting a long enough period of dead calm weather to finish dusting.

Last year we purchased 6 hand dusters which were used during tying down. These dusters weigh less than 3 pounds, contain sealed ball bearings, and are of a sturdy rotary-type construction. The duster holds over 1 pound of sulfur which is plenty for one tree. The duster is held by a wire hook on the workers belt to keep it out of his way during climbing and while moving about. The worker thins and ties each bunch in the palm and then dusts each bunch individually before leaving the crown of the palm. He refills the duster before proceeding up the next palm. This method is only economic while tying down but it does give excellent coverage even if a breeze is blowing.

We follow up with power dusting later on in June and July when humid, calm days are frequent. This type of hand duster is distributed by the Hudson Manufacturing Company and can be obtained locally.

VARIETY IN PACKAGE SIZE INCREASES DATE SALES[1]

Presented by Billy J. Peightal

Manager, Date Administrative Committee

As you know, the Committee continually is sponsoring research projects the scope of which extends from the farm to the consumer level. The basic objective of its efforts in this area, of course, is to secure new means or improvement in existing practices which ultimately will reflect in better grower returns. With the exception of one project which now is being conducted at the U.S.D.A.'s Fruit and Vegetable Laboratory in Pasadena, the Committee has not actively participated, in a monetary sense, in any research project. Rather, it has sought agencies to conduct research on projects it has outlined and then has given direction to these agencies. In this the Committee has achieved considerable success.

Today some results of the Committee's research efforts will be reported to you. Dr. Maier is conducting research on a project which originally was financially supported by the Committee and he will report on the date work which is being done at the U.S.D.A.'s Fruit and Vegetable Laboratory in Pasadena. Mr. Schiller, who this afternoon will report on the physical determination of date moisture, is employed by the Committee basically to develop new and improve on existing date products. This is in line with the Committee's efforts in finding the means to expand the market for dates. His work and report today on moisture determination is an outgrowth associated with the basic problem assigned to him. It is hoped that next year we will be able to give you a report on the pilot model electronic device which will sort dates according to moisture content as well as other projects.

This morning I should like to review a research report on some merchandising tests originally presented a few weeks ago by George H. Goldsborough, Head, Merchandising Methods Section of the U. S. Department of Agriculture. This report, entitled "Variety in Package Size Increases Date Sales" summarizes a merchandising experiment requested of the Department by the Committee. The experiment, the results of which you will see, was conducted in twelve supermarkets in the Boston area over a 16 week period. I believe the results are extremely significant and timely.

INTRODUCTION

In the marketing of agricultural products today, it is necessary that producers and distributors be flexible and adaptable to changes that develop in consumer habits and retailing policies. Because of the dynamic nature of food marketing, bringing about frequent and numerous changes affecting producers as well as retailers, it is most desirable to learn quickly the trends and be able to take advantage of them.

For example, the prepackaging of fruits and vegetables is gaining in importance. In the case of some commodities, such as dates, prepackaged items at the retail level represent practically all of total annual sales. No single consumer package size seems to satisfy the needs of all shoppers. The retailer must offer various package sizes in order to maximize sales. This was proved very conclusively in an apple merchandising study in Pittsburgh, Pennsylvania. The test display which offered various sizes of packages outsold the display that had only one package size. The same was true in tests with carrots, mushrooms, potatoes, and other commodities.

Marketing agencies should ascertain the package sizes most consumers desire and endeavor to insure that retailers carry these sizes to increase sales. Offering consumers the opportunity of purchasing the larger sizes, for instance, is likely to expand sales because, logically, the presence in the home of a larger package size of a commodity probably insures greater availability of that commodity to the consumer and thereby increases total consumption.

At the request of the Date Administrative Committee and with the cooperation of the California Date Growers Association and Stop & Shop, Inc., the U. S. Department of Agriculture included a 16-week experiment on domestic unpitted dates in a series of commodity tests conducted in Boston, Mass., during 1957. Throughout the remainder of my discussion, wherever "dates" are mentioned, I am referring to domestic unpitted dates, unless another type is specifically named.

As in prior merchandising studies, the purpose of the retail store research on dates was to measure and evaluate the sales effectiveness of selected methods of in-store merchandising. In controlled experiments at the retail level, consumer reaction to alternative practices can be accurately and quickly measured. In the merchandising methods used in the date test, consumers were offered various combinations of package sizes. The combinations were selected and developed after consulting with the date industry and the retail cooperator.

Unpitted dates were displayed in various package sizes. Combinations that were tested included the: (a) 12-ounce package alone; (b) 12-, 24-, and 32-ounce packages; (c) 12- and 32-ounce packages; and (d) 12- and 24-ounce packages. Method (a) was considered the "control" method because, at the time of the experiment, the normal practice of the retail cooperator was to display only one package size per store, either 12 or 16 ounces.

RESULTS

It will be noted that the display offering all three package sizes (12-, 24-, and 32-ounces) resulted in the largest quantity of sales (table 1). Sales were progressively less as the number of different size packages offered decreased.

Table 1—Sales of unpitted dates in 12 food supermarkets, Boston, Mass., April 22-August 10, 1957.

Merchandising method	Quantity sold Ounces
A—12-ounce packages	24,312
B—12-, 24-, & 32-oz. packages	39,124
C—12- and 32-oz. packages	29,432
D—12- and 24-oz. packages	28,140

For each display, 3 vertical rows of packages were used. For method A, the display consisted of 3 rows of 12-ounce packages. For displays of 12-, 24-, and 32-ounce packages, the row on the left was comprised of 12-ounce packages, the row in the center 24-ounce packages, and the row to the right 32-ounce packages. For displays of 12- and 32-ounce packages, the row on the left always contained 12-ounce packages, and the row on the right always contained 32-ounce packages. The additional row in the center contained the 12-ounce packages and the 32-ounce packages alternately and for the same length of time. This arrangement was necessary in order to insure equal exposure of the different package sizes to consumers. Displays of 12- and 24-ounce packages were handled in a similar manner.

[1] *This presentation is based on research conducted by Hugh M. Smith and Nick Havas of the Merchandising Methods Section in cooperation with the California Date Growers Association and Stop & Shop, Inc., Boston, Mass.*

Table 2—Comparison of unpitted date sales in each of four selected merchandising methods in 12 food supermarkets, Boston, Mass., April 22-August 10, 1957.

Merchandising method	Quantity sold Ounces	Sales increase over method A Percent
A—12-ounce packages	24,312	0
B—12-, 24-, and 32-ounce packages	39,124	60.9
C—12- and 32-ounce packages	29,432	21.1
D—12- and 24-ounce packages	28,140	15.7

Table 3—Level of differences between merchandising method "A," the smaller 12-ounce package, and methods "B," "C," and "D" containing larger package combinations.

Selected merchandising methods	Number of times out of 100 that method indicated in left column should be better than method "A," 12-ounce packages
B—12-, 24-, and 32-ounce packages	99.99
C—12- and 32-ounce packages	86.
D—12- and 24-ounce packages	75.

Table 4—Size of unpitted date packages used in 12 food supermarkets, Boston Mass., April 22-August 10, 1957

Weight of package Ounces	Length Inches	Width Inches	Height Inches
12	6¾	4¼	1¼
24	8¾	5¾	1⅜
32	10⅛	6¾	1½

Table 5—Sales of unpitted dates by size of package in 12 food supermarkets Boston, Mass., April 22-August 10, 1957

Merchandising method	Size of package Ounces	Packages sold Number	Ounces sold Number
A[1]	12	2,026	24,312
B	12	1,403	16,836
	24	426	10,224
	32	377	12,064
C	12	1,482	17,784
	32	364	11,648
D	12	1,283	15,396
	24	531	12,744

[1]Merchandising methods tested are as follows:
A—12-ounce packages
B—12-, 24-, and 32-ounce packages
C—12- and 32-ounce packages
D—12- and 24-ounce packages

Figures have been presented up to this point in terms of quantity sales. In the last column of the table it will be noted how these sales results compare on a percentage basis (table 2). The display containing the three sizes of packages resulted in 61 percent greater sales than the display of 12-ounce packages alone. Sixteen to 21 percent greater sales were obtained by using 2 package size combinations instead of the 12-ounce packages alone.

The price of dates remained the same during the entire experiment at 19 cents per 12-ounce package; 39 cents for the 24-ounce package; and 49 cents for the 32-ounce package—about the same price per ounce regardless of the size of package. If the consumer could benefit from a price advantage by purchasing the larger size package, total sales, where larger packages were displayed, might be greater than reflected in the experiment.

Because certain uncontrollable variables and experimental errors are normally present in conducting marketing research, statistical reliability tests were performed to indicate the validity of the findings or the confidence that can be placed in the results, based on the experimental design established for the experiment. These tests indicate that greater sales should result at least 99.99 times out of 100 by using the 12-, 24-, and 32-ounce unpitted date package combination rather than a display of 12-ounce packages alone; 86 times out of 100 by using the 12- and 32-ounce package combination; and 75 percent of the time by using the 12- and 32-ounce package combination (table 3).

Statistical reliability tests were also performed to determine what percent of the time the three package combination could be expected to produce larger sales than either the 12- and 32-ounce or 12- and 24-ounce combination. It was found that the three package combination should result in greater sales than either two package combinations about 99 times out of 100.

Statistical reliability tests to ascertain the likelihood that the 12- and 32-ounce combination would result in greater sales than the 12- and 24-ounce combination did not indicate that the 12- and 32-ounce combination could, with confidence, be expected to outsell the 12- and 24-ounce combination. In other words either combination, saleswise, should be about as effective as the other.

Although sales are maximized by using 3 sizes of packages, the fact that displays offering 2 sizes of packages are also likely to have greater sales effectiveness than displays with the smaller package alone is an important finding to retailers and to you in conducting dealer service work with the trade. For instance, some retailers carrying one package size may be averse to carrying two additional items in stock and may be satisfied with increasing sales to a smaller degree by carrying only 2 size packages. This will be primarily true of stores which wish to display less than 3 vertical rows of date packages. A grocer may feel that carrying one to two additional package sizes will increase his over-all cost slightly because it necessitates his ordering, stocking, and displaying more variety to increase sales.

The retailer also has to consider space utilization in carrying the larger size packages since they occupy somewhat more display area (table 4). For example, using 3 vertical rows of dates, the combination of the three different package sizes tested would occupy a linear frontage of approximately 25 inches compared with 20 inches when 3 rows of the 12-ounce packages are displayed. Thus the 61 percent increase in sales using 3 versus 1 package size requires about 5 linear inches more (an increase of about 20 percent). The 12- and 32-ounce displays would occupy 25 inches and the 12- and 24-ounce combination 23 inches, using 3 vertical rows in the same manner as in the Boston test; i.e., using the center row for the smaller and larger package an equal amount of time.

Even with the possible slight cost consideration and the space utilization factor involved, many retailers are likely to look with favor on carrying additional sizes if they know through research results that significant sales increases are probable.

When the 12-, 24-, and 32-ounce packages were displayed together it will be noted that the more than 50 percent of the dates sold were in the larger size packages (fig. 1). Forty-three percent were sold in 12-ounce packages.

Irrespective of the merchandising method displayed, a larger volume of dates moved in the small size package than in any other one size of package (table 5). It will be noted, however, that in merchandising method D, where the 24-ounce package was offered, 45 percent, or almost half of the total quantity in ounces, was sold in the larger size containers. In merchandising method C, where the 32-ounce package was offered, 40 percent of the total quantity, in ounces, was sold in the larger size container.

OBSERVATIONS OF TOTAL SALES OF UNPITTED AND PITTED DATES

The final publication covering the results of this experiment will indicate the effect, if any, of the sale of pitted dates on the sale of unpitted dates. At present we are only in a position to report the relative total weekly movement of both type of dates during the course of the experiment.

A normal stock of domestic pitted dates was carried in the test stores during the first half of the date experiment along with domestic unpitted dates. Prior to the end of the experiment, the stocking of pitted dates was discontinued by the cooperating chain. Pitted dates were shifted between test stores to assure that the stocks in all stores would be depleted at approximately the same rate and discontinued at the same time to equalize the effects on unpitted date sales.

During the first 8 weeks, when both pitted and unpitted dates were available in normal quantities, approximately two-thirds of the total sales of domestic dates were unpitted and one-third pitted (fig. 2).

During the latter part of the experiment when pitted dates were no longer available, total sales declined by about the same extent as pitted sales. The decline in pitted sales was in direct relation to the decline in stocks and eventual complete nonavailability to the consumer. Customers who were seeking to purchase pitted dates and found none on display or missed seeing them because of partial display had 3 alternatives: (1) to purchase unpitted domestic dates, (2) to purchase imported dates, and (3) to bypass purchasing dates completely. We do not know what percent did each of the alternatives but it seems logical to assume that total sales of domestic dates decreased because of this nonavailability. In your dealer service work with retailers, it would appear worthwhile to stress the advisability of maintaining adequate displays of pitted as well as unpitted fruit. In this connection, of course, it is necessary that you be in a position to give assurance that the retailers can count on sufficient supplies to fill their needs.

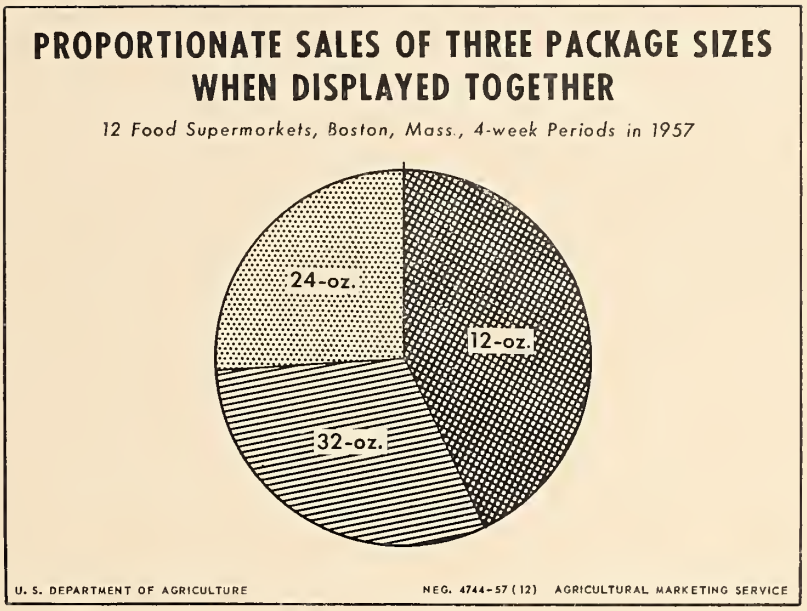

Figure 1

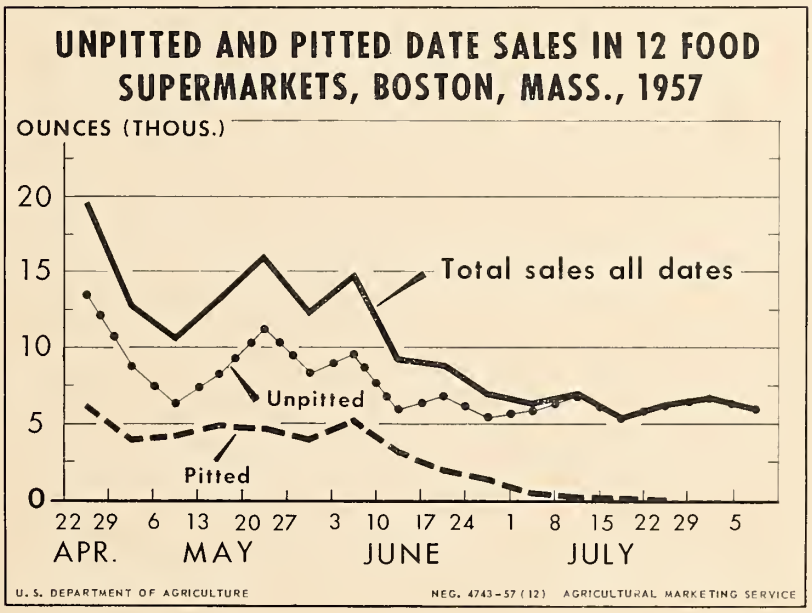

Figure 2

METHODOLOGY

You might be interested in a brief description of the techniques used in this controlled experiment (fig. 3).

Figure 3—The latin square design used in measuring the effect of specified merchandising methods on retail stores of selected commodities.

Time period	Stores 1	2	3	4
1st	[1]A	B	C	D
2nd	B	C	D	A
3rd	C	D	A	B
4th	D	A	B	C

[1]Alphabetical letters in this design represent specified merchandising methods.

A rotational arrangement was used in the experimental testing of alternative methods of merchandising domestic dates (fig. 3). By rotating the merchandising methods being tested from store to store, the effect on retail sales of nontest variables—differences in size and type of stores, seasonality of demand, competition from other products, and differences in preference of customers among stores—was essentially equalized. The effect of certain other variables on the volume of sales was eliminated by holding the variables constant throughout the experiment in all test stores. For example, the number of rows of dates, the location, and type

of display were kept constant throughout the test periods by prior arrangement with officials of the test stores. Prices did not change during the test period and were uniform for all stores. There was no advertising on dates on the part of the retail cooperator during the test period. In addition, retail practices and policies applying to competing fruit, as well as dates, were relatively uniform since all stores were supermarkets under the same chain store management and in the same metropolitan area.

The 4 methods of merchandising domestic unpitted dates were tested in 12 stores in 3 groups of 4 stores each. The experimental test period was of 16 weeks' duration. Each merchandising method in each store was rotated every 4 weeks so that after 16 weeks each merchandising method was tested for a 4-week time period in all stores.

Data were gathered under normal store operating conditions. Consumers were exposed to only one merchandising method in a store at a time. An enumerator was assigned to each store and was responsible for maintaining date displays in the prescribed manner for each merchandising method, according to the rotation schedule. In addition, they collected records of sales and spoilage, and obtained a customer count per store.

During the test, the number of stores occupied by each of the different package size combinations was the same. Further, as indicated earlier, each size of package within each combination was exposed to potential customers for an equal length of time.

This summarizes the important findings of the test. Additional analyses are being conducted and will be included in a publication to be issued later.

I think we should all be grateful to the California Date Growers Association for providing the test packages and to Stop and Shop, Inc., for its cooperation in providing 12 supermarkets as a "laboratory" for the experiment and in assisting the researchers to maintain the displays in accordance with the requirements of the test. Without such cooperation it would be extremely difficult to accomplish worthwhile marketing research.

"SAMPLING OF SOME DATE PRODUCTS"

By Hillman Yowell

California Date Growers' Association, Indio, California

For the last part of the program the meeting adjourned to the school cafeteria nearby. There members of the Date Institute were guests of the California Date Growers' Association who served coffee and invited all present to sample, as well as inspect, a large assortment of date products displayed for the occasion. Mr. Yowell, plant manager of "Caldate," explained that the attractive array of various cakes, cookies, stuffed dates, etc., were all the results of a research program that is being conducted by his organization to originate new and better food products in which dates are a major ingredient.

DATE RESEARCH PROGRAM AT THE PASADENA LABORATORY

V. P. Maier and Frank H. Schiller[1]

Fruit and Vegetable Laboratory, Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, Pasadena, California

This laboratory has been active in date research on a number of occasions in past years. As far back as 1933, the old laboratory in Los Angeles did considerable work on problems of the date industry. In more recent years this same laboratory developed a method of canning and pasteurizing dates (2). The present date research program at the Pasadena Laboratory was initiated in June, 1956, through a cooperative agreement with the Date Administrative Committee to study the chemical composition of dates in an effort to discover the causes of darkening during storage. Late in 1957, the date research work underwent a two-fold expansion. In addition to the basic compositional studies, work was started on the development and uses of improved date products.

In conjunction with this expansion of the project a comprehensive research program was formulated to serve as a guide for the next several years. The purpose of this paper is to present and discuss this program and to briefly report on the progress made up to the present time.

The program outlined below includes a short and a long term approach to chemical changes associated with deterioration during the storage of dates, and the development of new and improved products.

CHEMICAL CHANGES ASSOCIATED WITH DETERIORATION

Darkening is one of the most important quality changes associated with the deterioration of dates during storage. Unfortunately, there are no good quantitative methods available at the present time for measuring the degree of darkness of dates. Therefore, one of the first studies undertaken was the development of methods for measuring this change. Thus far, a method has been developed which involves removal of the dark pigments by extracting the dates with a solvent. Darkness of the extract is then determined by means of a photoelectric colorimeter. Using this method, which has a reproducibility of $\pm$ 2 percent, the presence of a 10 percent increase in the darkness of dates can be detected. This method is useful in determining the total amount of extractable pigments and, as a result, gives an average darkness value of the dates. Darkness as determined by extraction methods does not always bear a direct relationship to the visually estimated darkness. A date which has darkened only in the surface layers of tissue will give a much lower result with this method than one which has darkened thoughout, yet both dates may appear to be equally dark visually.

For research purposes it is highly desirable to have a method of measuring the surface darkness of dates (reflectance). An instrumental method with which such a measurement can be made is presently being developed. It involves the use of a reflectance meter coupled with a special device for presentation of the sample. It is expected that this instrument will make possible the precise determination of the surface darkness of dates, both singly and in groups of ten. An instrument of this type might be adapted for use in quality control work by the industry.

Since the moisture content of dates has been shown to have an influence on their deterioration (7, 8) the availability of methods to measure this property rapidly and accurately is important in both deterioration studies and in product development work. These methods also might find uses as quality control measures by the industry. A study of several rapid physical methods of measuring moisture has been completed and is published elsewhere in this report.

Very little is known concerning the chemistry of the darkening process in dates. Several environmental factors have been shown to influence darkening including oxygen, moisture content and temperature, but the chemical basis for these effects remains obscure. Rygg (7, 8) has found that the rate of darkening increases with increased moisture content and temperature. Associated with the darkening was an increase in acidity and a loss of fresh flavor and odor. Neilsen, *et al.* (2) obtained variable results when studying the effect of oxygen on the darkening process. In one experiment in which dates were pasteurized and stored in both the presence and absence of oxygen this gas greatly increased darkening; however, in a second similar experiment little difference was reported. Rinderknecht (4) observed that dates packed in the absence of oxygen darkened much less than those packed in the presence of oxygen.

Stadtman, *et al.* (9) found that the rate of darkening of apricots decreased with increased moisture under a nitrogen atmosphere; whereas, if oxygen was freely available the rate of darkening increased with increased moisture. If this or a similar situation exists for dates it would help explain the conflicting results mentioned previously.

In the case of walnuts, deterioration involves a darkening of the outer skin, along with the development of off-odors and flavors. Rockland (6) found that this deterioration of shelled walnuts could be greatly reduced by adjusting the moisture content to an optimum value, coating with antioxidants and packaging in Saran film bags under nitrogen.

In view of these facts, our first approach to the chemistry of darkening was based on the theory that it was primarily an oxidative process and therefore should be prevented by any treatment which prevented oxygen from coming into contact with dates. Two different methods were tried, one of which involved storing dates in the absence of oxygen and the other involved coating dates with various antioxidants and film-forming materials. Unfortunately, neither of these methods proved to be successful. Dates stored in the absence and presence of oxygen darkened at almost the same rate. The coated dates, in like manner, darkened as rapidly as the uncoated samples. Thus, the darkening of these dates was not primarily an oxidative process. It is apparent from this work and that mentioned previously that other factors have an important and sometimes controlling influence over the effect of oxygen on the darkening process.

The foregoing examples emphasize the need for more detailed information concerning the chemical changes associated with deterioration in dates. In addition to determining what these chemical changes are, it is important to know what effects environmental factors have on them. To obtain information of this type, a comprehensive study of some of the gross chemical changes which occur during deterioration will be made. The rates of darkening, sucrose inversion, pH change, oxygen uptake and carbon dioxide evolution will be determined. In addition, the effects of moisture, oxygen, temperature, light and enzyme activity on these changes will be evaluated. This information should lead to a better understanding of the reactions of the

[1] *Employed by the Date Administrative Committee under a Memorandum of Understanding.*

deteriorative processes, which in turn should lead to new or improved methods of preventing this quality loss.

Long term studies on the chemical composition of dates as related to darkening are being continued. These studies differ from those mentioned above in that they are concerned not with the gross chemical changes, but rather with the changes in the individual chemical constituents of dates. Rinderknecht (3) has recently completed the analysis of the free amino acids present in dates during maturation and storage. He found 16 amino acids to be present. With regard to quantitative changes during maturation and storage, these 16 amino acids could be grouped into four general patterns. Five of them remained unchanged during maturation, while two increased, and four others decreased in amounts. The fourth group increased up to the red stage and then decreased. In connection with this work, Rinderknecht and Jurd (5) observed a new type of browning reaction between one of the amino acids of dates and phloroglucinol, a polyphenolic compound, which could be of great importance in the darkening process. The presence of phloroglucinol, or its derivatives, has been suspected in dates for a number of years (10); however, definite proof of its presence is still lacking. Because of the importance of polyphenols in the darkening of other fruits, and in order to follow up this lead, the polyphenolic constituents of dates are presently being investigated.

Thus far, the polyphenolic constituents have been extracted from green dates and a crude tannin (polyphenol) isolated. This material has two major components, one of which appears to be a catechin tannin. Preliminary evidence also indicates the presence of several flavonoid compounds in the extract. When the pure polyphenols are isolated and identified their chemistry will be investigated with special attention given to those reactions which lead to the production of dark products. By an approach such as this it is expected that some of the basic chemistry of the darkening process in dates can be unraveled. Specific chemical knowledge of this darkening process will be extremely helpful in devising methods of preventing this quality loss in dates. Future plans call for the investigation of the enzymes and organic acids of the date.

DEVELOPMENT OF AND USES FOR IMPROVED PRODUCTS

The different types of date products which have been produced at one time or other are too numerous to list here. They range from syrups to butters to pieces of almost any size, shape or moisture content. The same situation holds for the uses to which dates and date products have been put in various manufactured food products. In addition to the date growers and packers, Cruess (1) was active in this field for a number of years. A study of the problem revealed that dehydrated pieces and powder account for the major proportion of dates going into products. This is not surprising when the inherent stability and adaptability of a dehydrated product is considered. In view of these facts an attempt will be made to develop new and improved dehydrated date products through the application of improved methods of dehydration. In the case of uses for dates and dehydrated date products, several items have been chosen which appear to have the greatest promise both from the development and consumer acceptance points of view. These include date spreads, ice cream, syrups and confections.

The main objective of one phase of the work is to develop dehydrated products which will have good appearance and flavor; rehydrating, handling and storage properties; and which can be used in the production of many types of date-flavored products such as baked goods, ice creams, confections, etc. Various methods of dehydration such as puff-drying and drum-drying will be applied toward this end.

Puff-drying is a process developed at the U.S.D.A., Western Utilization Research and Development Division at Albany, California, for the production of high quality fruit juice powders. It involves the use of vacuum to cause the material to puff up followed by the application of heat to dry it. The result is a sponge-like, porous product with good flavor and rehydrating properties. Preliminary results with dates have been promising.

Drum-drying is a continuous process used for drying materials of high fiber content and for this reason it will probably be more easily adapted to use with dates. In this process the material is continuously spread in a thin layer over the surface of a rotating, heated drum. Because of the large contact area between the heating surface and the material, the drying proceeds rapidly.

Preliminary work has been done on the development of new and improved uses for dates. Several spreads have been made which have met with the approval of all who have tasted them. These spreads include combinations of dates with peanuts, walnuts and almonds. They might find application in the baking industry as fillings for cookies, cakes or pastries, or for use directly by the consumer as spreads for bread. An improved date syrup which has good color and fresh date flavor also has been developed. The high quality of this item suggests its use as a table syrup. Both the spreads and the syrup are undergoing storage tests at the present time.

Through a cooperative arrangement with the U.S.D.A., Southern Utilization Research and Development Division in New Orleans various date products are being evaluated for use in confection formulations. Date-filled confections are now being prepared and when perfected their formulas will be made available to the industry. If necessary, new date products will be developed if the present ones are found to be unsatisfactory for this purpose.

The development of a date ice cream made by the ripple-process is being conducted with the cooperation of the Carnation Company. In this process a heavy date syrup-paste mixture is folded into a vanilla base ice cream to give a marbled effect. In date-ripple ice cream the date material will occur in concentrated veins scattered throughout the vanilla ice cream. These concentrated areas of date material scattered throughout the ice cream should give a better overall date flavor than that obtained by the presently used even distribution method in which the major part of the date material forms a homogeneous part of the ice cream.

LITERATURE CITED

1. *Cruess, W. V.* 1940. *Date and Date Products in Egypt and California. Date Growers' Institute Ann. Rept.* 17: 20-27.
2. *Nielsen, B. W., McColloch, R. J. and Beavens, E. A.* 1950. *Processing and Packaging of Dates. I. A New Method of Canning and Pasteurizing Deglet Noor Dates. Food Tech.* 4: 232-237.
3. *Rinderknecht, H. The Free Amino Acid Pattern of Dates in Relation to Their Darkening During Maturation and Storage. In Preparation.*
4. *Rinderknecht, H. Personal Communication.*
5. *Rinderknecht, H. and Jurd, L. A Novel Non-Enzymatic Browning Reaction. In Press.*
6. *Rockland, L. B.* 1955. *Recent Progress on the Utilization of Shelled Walnuts. Diamond Walnut News* 37: No. 5, 12-17.
7. *Rygg, G. L.* 1956. *Effect of Temperature and Moisture Content on the Rate of Deterioration in Deglet Noor Dates. Date Growers' Institute Ann. Rept.* 33: 8-11.

8. *Rygg, G. L.* 1957. *The Relation of Moisture Content to Rate of Darkening in Deglet Noor Dates. Date Growers' Institute Ann. Rept.* 34: 12-13.

9. *Stadtman, E. R., Barker, H. A., Mrak, E. M. and Mackinney, G.* 1946. *Storage of Dried Fruit, influence of moisture and sulfur dioxide on deterioration of apricots. Ind. Eng. Chem.* 38: 99-104.

10. *Turrell, F. M., Sinclair, W. B. and Bliss, D. E.* 1940. *Structural and Chemical Factors in Relation to Fungus Spoilage of Dates. Date Growers' Institute Ann. Rept.* 17: 5-11.

CONTROL OF THE DATE MITE, OLIGONYCHUS PRATENSIS (BANKS), IN CALIFORNIA

L. E. Vincent and D. L. Lindgren

University of California Citrus Experiment Station, Riverside

The date mite was originally described in 1914 by Banks as *Tetranychus simplex* from date palms at El Centro, California. Since this time it has been variously known as *Paratetranychus heteronychus, Paratetranychus simplex, Paratetranychus pratensis,* and has now been determined by E. W. Baker of the U. S. Department of Agriculture, as *Oligonychus pratensis* (Banks), and the approved common name is the date mite. Apparently, this is the only mite attacking date palms in the Coachella and Imperial valleys. The biology of this mite and its host range have been worked out by Stickney, Barnes, and Simmons (1950).

The date mite rasps the surface of the host tissue and injures the fruit by scarring the skin and thus causing it to harden, crack, and shrivel. As the old tissue on the surface of the date becomes hard and cracks, the mite colony gradually spreads over more surface, or new colonies are started close by.

The date mite is a small flesh-to-pale - amber - colored species which spins a very fine, dense webbing over the surface of the dates. The webbing is easily detected on the fruit, but the mite, being very small, is difficult to see. The translucent white-to-pale-amber eggs of the mite are deposited on the surface of the date fruit among the fibrils of webbing, and the entire life cycle is passed within or beneath or along the edges of the web.

The date mite is present in all stages of development throughout the year. During the winter its activity is much reduced, and its numbers decrease as the cold season advances. With the advent of warm weather it begins to increase in activity and in numbers and it maintains a high rate of activity throughout the warmer part of the year. Usually by June the mites are abundant on the dates. Infestations in a garden are generally spotty, some bunches being heavily infested and others having few or no mites present, but observations indicate that the heaviest infestations are found on those palms bordering dusty roads. When the fruit ripens in the fall, the date mites diminish in numbers but persist behind the fiber on the white tissue of the leaf bases, particularly on the younger leaves, and on grasses, in sufficient numbers to ensure infestations the following year.

This mite is tolerant of sunshine, but under high temperatures it seeks protection. Both nymphs and adults are easily disturbed and may then float off into the air attached to a thread of silk. They are able to cling to bare host tissue through a rather strong wind.

Date mites are able to build up large populations only on the date fruit, where concentrations are much greater than on grasses. Although the mites readily attack dates from the time of their earliest formation until the fruit begins to change color as the ripening process sets in, they usually do not infest mature fruits.

Colonies of the date mite in the fruit bunch usually begin to form between two date fruits or between the base of a date and the strand to which it is attached. As the colonies grow, the infested areas spread and are likely to cover the entire fruit surface. Whole bunches of fruit may become enshrouded with webbing.

Dates that are only lightly infested, as is the case when the mites are destroyed by early treatment, ripen normally, and although the injured surfaces remain discolored, the damage does not extend beneath the skin of the fruit. Such dates are edible, but they cannot be rated as first-class fruit. As infestation increases, the fruit skin becomes roughened and hard, and injury extends to the tissue beneath the surface. A small colony may increase so rapidly that serious damage results within 2 or 3 weeks.

Mite-damaged surfaces are likely to crack after a rain or if exposed to the sun. Heavy deposits of dust collect in the webbing. Severely infested dates do not develop properly, owing not only to the direct damage caused by the feeding of the mites, but probably also to the abnormal conditions induced by the sheets of dusty webbing.

The date mite assumes added significance because the fruit of the important Deglet Noor variety is very susceptible to the attack of this mite. On the other hand, some varieties such as the Khadrawi are nearly free from infestation.

The date mite has also been identified as infesting several grasses in the Coachella valley. The mites infest both sides of the grass blades at the base and often cause them to turn pale and to dry out. The plants do not die, however, since small areas are attacked and the root stocks are not reached.

According to Walter (1956), this mite has caused injury to dent corn throughout the lower Rio Grande Valley. Specimens of this mite were found in most of the grasses and sedges, and in many of the weeds in a heavily infested field of corn. From reports received during 1954-55, this mite is rather generally distributed throughout the states west and south of Kansas, and is a threat to grain sorghum as well as to field and late sweet corn. It has been found on wheat in Kansas and as a most injurious pest of wheat in eastern New Mexico, 1952. It is now recorded from Arizona, Idaho, Florida, Kansas, Montana, New Mexico, Texas, Virginia, Washington, and California.

According to Stickney (1924), the date mite is easily controlled during the season by a nico-sulfur dust or a cresylic-distillate emulsion (the standard formula for Marlatt scale), which has been tried with success. The treatment for many years has been thorough coverage with sulfur dust applied as soon as the date mites appear, usually between the first of May and the middle of June. Airplane applications are frequently used early in the season, but almost invariably must be followed by an application from the ground directly into the bunches after they have been tied down.

Investigations on the control of date mite have been conducted by the Department of Entomology of the University of California Citrus Experiment Station since 1948 to evaluate the new acaricides as they became available, using sulfur-dust treatment as a basis for comparison. Each year, early in the season, date-mite-infested Deglet Noor bunches are located and observed weekly. After the bunch has become heavily infested and injury to the fruit is eventual, the dusts are applied with a rotary hand duster. The date palms selected are generally low, to facilitate application and observation. Such palms have usually been located adjacent to dusty roads. Records of infestation are made prior to treatment and at weekly intervals following treatment. For each series of acaricides used, a control tree (undusted) is retained. If these controls become too heavily infested or if a treatment fails, the bunches are then dusted with sulfur to prevent further fruit injury. A microscopic examination of the infested dates in each treatment was made to determine the presence of living mites. In general, the new growth of the date fruit and the disintegration of the date-mite webbing indicate that the date-mite infestation has been effectively controlled.

A summary of the results of experimental screening application of new acaricides against the date mite, 1948-1956, is given in table 1 (Darley, et al, 1952; Lindgren & Vincent, 1949; Lindgren, et al, 1951; Vincent & Lindgren, 1950; and Vincent and Lindgren, 1956). Neither of the two compounds tested in 1948 was effective. Of 16 materials tested in 1949 and 1950, only Dimite at 4 per cent gave any degree of control; however, this treatment severely injured the fruit. Of the seven compounds evaluated in 1951, none controlled the date mite. Of the five materials tested in 1955, only Trithion and Kelthane appeared to be effective and were retested in 1956 with similar results. These two materials have caused no fruit injury.

Table 2 shows the results obtained with sulfur during this same period. A single sulfur dusting controlled the mites for the duration of the observation period and was as effective in 1956 as in 1948. Sulfur was used as the basis of comparison in these experiments, and although Trithion and Kelthane were effective against the date mite, they were no better than sulfur. Several brands of dusting sulfur were used during the experimental period, with no difference observed in application or results obtained.

Some date growers have, for the past several years, felt there might be a variation in sulfur brands available for dusting. Sulfur is an element and, as such, its composition does not change except through volatalization. According to Special Publication No. 258, State of California (1954-55), a pesticide must be registered before it may be offered for sale in California. Examination of the proposed composition and the proposed labeling serves (a) to ensure adequate labeling providing suitable directions for use and any necessary precautionary information on acceptable products, and (b) to screen out unfit materials before they are marketed. Registration may be withheld if the proposed product is worthless or if it presents an intolerable hazard. Official samples are drawn from pesticides found in possession of registrants, dealers, or users, and are tested for guaranteed composition.

Table 3 lists 12 different brands of dusting sulfur and shows the percentage of sulfur guaranteed and that found, as well as the percentage guaranteed to pass through a 325-mesh screen and the amount found. It will be noticed that the percentage of sulfur found was above that guaranteed. Where the information was available, the amount passing through a 325-mesh screen was found to be greater than that guaranteed on the label.

Our observations indicate that, on a cost-per-acre basis, sulfur is the most effective date-mite treatment, but the dust must be forced up into the bunch to give good control. A dust drift such as that obtained by driving through the garden with a power or hand duster, blowing the sulfur among the palms, or by airplane dusting, although giving some degree of control, does not provide a control to compare with that obtained when the sulfur is blown upward, directly into each bunch, depositing a film of dust over the

Table 1—Summary of results of experimental screening applications of new acaricides on the date mite, 1948-1956.

Acaricide	Per Cent Applied as a Dust	Year Tested	Days Effective
Parathion	2	1948	0
K-1875	2	1948	0
K-6,451	4	1949	0
Aramite	4	1949	0
EPN	4	1949	0
Genitol 923	4	1949	0
CS 645-A	4	1949	0
Karathane	4	1949	0
Dimite	2	1949	0
Dimite	4	1949	28[1]
Pestox III[2]	..	1950	0
Dieldrin	1	1950	0
5571	5	1950	0
5572	5	1950	0
5860	5	1950	0
Malathion	5	1950	0
Sulphenone	5	1950	0
Dimite	4	1950	19[1]
Malathion	5	1951	0
Sulphenone	5	1951	0
Thiocide	5	1951	0
Thiocide G	5	1951	0
EPN	5	1951	0
MR30	5	1951	0
Systox[2]	..	1951	0
Trithion	25	1955	28
Kelthane	4	1955	28
Mitox	20	1955	0
AC-528	2	1955	0
Chlorobenzilate	4	1955	0
Trithion	5	1956	40
Kelthane	5	1956	40

[1]Severe fruit injury.
[2]Applied as sprays at 1 pint per 100 gallons of water.

Table 2—Summary of results of control experiments with sulfur on the date mite, 1948-1956.

Year Tested	Days Effective
1948	35
1949	43
1950	41
1951	42
1955	40
1956	40

surface of the dates. Complete and thorough coverage is especially important if there is any date-mite webbing present at the time of dusting. The only disadvantage of using sulfur is the irritation to the eyes and skin of the person applying the dust.

Table 3—A comparison of various brands of dusting sulfur.

Brand No.	Sulfur, Per Cent		Per Cent Passing 325-Mesh Sieve	
	Guaranteed	Found	Guaranteed	Found
1	98.00	98.06		
2	98.00	97.97		
3	98.00	98.72		
4	97.50	98.85	95.00	97.99
5	98.00	98.87	95.00	97.23
6	98.00	98.92		
7	98.00	98.24		
8	94.00	96.57	95.00	99.87
9	99.00	99.38		
10	98.00	99.36	95.00	98.81
11	98.00	98.27	95.00	97.05
12	98.00	99.37		

LITERATURE CITED

Darley, E. F., D. L. Lindgren, L. E. Vincent, and W. D. Wilbur. 1952. *Report on date fruit spoilage. Date Growers' Inst. Ann. Rept.* 29:4-5.

Lindgren, D. L., and L. E. Vincent. 1949. *Investigations on the life history and control of date insects and the date mite. Date Growers' Inst. Ann. Rept.* 26:21-24.

Lindgren, D. L., L. E. Vincent, and P. D. Gerhardt. 1951. *Report on date-insect and date-mite control investigations. Date Growers' Inst. Ann. Rept.* 28:4-5.

State of California, Department of Agriculture. 1954-55. *Pesticides—economic poisons. Bureau of Chemistry Special Publication No.* 258. 180 pp.

Stickney, F. 1924. *Date palm insects. Date Growers' Inst. Ann. Rept.* 1:16-17.

Stickney, Fenner S., Dwight F. Barnes, and Perez Simmons. 1950. *Date palm insects in the United States. U. S. Department of Agriculture Circular No.* 846. 57 *pp.*

Vincent, L. E., and D. L. Lindgren. 1950. *Progress report on control of date insects and the date mite. Date Growers' Inst. Ann. Rept.* 27:3-7.

Vincent, L. E., and D. L. Lindgren. 1956. *Progress report on control of date insects. Date Growers' Inst. Ann. Rept.* 33:3-4.

Walter, E. V. 1956. *Oligonychus pratensis, a new mite on corn. Jour. Econ. Ent.* 49(2):265-266.

MORPHOLOGICAL EFFECTS OF SPECIFIC POLLENS AND FRUIT THINNING ON FRUIT OF DEGLET NOOR DATES—A PROGRESS REPORT

By C. A. Schroeder and R. W. Nixon

University of California, Los Angeles, and U. S. Date Field Station, Indio

The remarkable effect of specific pollens on other than embryo or endosperm tissue of date fruit, first clearly demonstrated by Nixon (2), not only has proved of exceptional theoretical interest but has been shown to have sufficient significant practical application to be employed by some commercial growers under certain conditions. The phenomenon was termed "metaxenia" by Swingle (5) and has become widely known by this name though some workers have referred to the phenomenon as heterosis. It is to be distinguished from the response termed "xenia," which in current usage implies effects of pollens on endosperm tissues or the specific genetic effects of pollen on the hybrid embryo.

The manifestations of metaxenia in the date have been described by Nixon (3). It has been demonstrated that pollens from specific male clons produce certain responses in date fruit compared with pollens taken from certain other male trees. One of these effects is the shortening of time required for the fruit to attain horticultural maturity. Thus pollen of a Fard seedling (No. 4) will cause fruit to mature 10 days to eight weeks earlier than comparable fruit pollinated with other pollens such as Crane applied at the same time. Another striking effect is a decrease in fruit size when Fard pollen is used (3). An increase of fruit size as a response to fruit thinning has also been well demonstrated by Nixon and Crawford (4). These specific pollen and fruit thinning effects have been described and demonstrated, but the explanation of the basis concerned with the phenomena is lacking. A general theory proclaims the metaxenia effect as the response of the female tissue to growth hormones or auxins introduced into the ovary by the pollen source. The present investigations were designed to obtain basic information concerning the question: Does the increase in fruit size result from larger cells or simply the production of more cells in the pollen-affected or the thinned fruit?

MATERIALS AND METHODS

The present study was made on fruits of the variety Deglet Noor from palms at the U. S. Date Field Station, Indio. In March, 1957, 16 inflorescences, 4 on each of 4 palms, were selected for experimental pollinations. Each inflorescence was divided into two halves. Fard pollen was applied to one half and Crane pollen to the other half. In addition, 8 of the inflorescences, 2 on each of the 4 palms, were "lightly thinned" by cutting back the tips of the strands enough to remove about one fourth of the flowers and the other 8 inflorescences were "heavily thinned" in the same manner by the removal of half of the flowers. In accordance with current commercial practice, entire strands were removed from the center of each bunch so as to reduce the total number of strands about one-third. Fruit samples were taken from each of the two thinning treatments and from each of the two pollen sources when the fruits in the particular inflorescence-half reached the peak of the khalal stage. This was August 7 for the Fard samples and August 19 for the Crane samples. Three average fruits from each treatment on each inflorescence were selected as a sample. The pericarp wall was cut with a knife blade, the seed removed, and the fruit placed in a solution of formalin-acetic-alcohol. Some of the fixed and preserved fruits were prepared as permanent microscope slides. Other samples were cut free hand, stained with thionin, and mounted temporarily for measurement and observation.

The dimensional data were obtained by sketching an outline of the cells or tissues on paper with the aid of a camera lucida. This permits a permanent record of the observation from which measurements and calculations can be made at leisure. Observations were made of both cross and longitudinal sections.

OBSERVATIONS

The date fruit is botanically a berry with a soft fleshy wall enclosing a single elongated seed comprised of hard bony endosperm. The small white embryo is embedded centrally in the endosperm on the side opposite the groove. The pericarp or fruit wall consists in general of three regions: the outer mesocarp, the tannin cells, and the inner mesocarp. Just under the single layer epidermis is a hypodermal layer 4 to 6 cells in depth. Beneath the hypoderm is a layer of radially elongated stone cells which form the limit of the outer mesocarp, a layer of parenchyma approximately 15 to 25 cells wide. Next is a layer of prominent tannin cells three or four cells deep, which are distinguished by their very large size and massive tannin content. The remainder of the tissue between the tannin cells and seed cavity is the inner mesocarp comprised of parenchyma and forming the greater bulk of the edible portion of the fruit.

The morphological development of the date fruit from pollination to maturity as described by Long (1) is comprised of seven periods during which cell division occurs for a period throughout the ovary wall and at a subsequent period is restricted to a basal meristematic region. Cell enlargement then follows in all regions.

The direct effect of Fard pollen, which induces the production of smaller fruit, compared with Crane pollen is shown in Table 1. Fruit thinning in contrast, regardless of pollens used, resulted in comparatively larger fruit.

Table 1—Relation of fruit size to cell size (length) of Deglet Noor dates as affected by pollen and fruit thinning.

Pollen	Thinning*	Fruit length (centimeters)	Cell length (microns)
Fard	L	4.29 ± 0.06	31.6 ± 0.46
Fard	H	4.60 ± 0.06	34.4 ± 0.47
Crane	L	4.74 ± 0.19	29.3 ± 0.41
Crane	H	5.04 ± 0.07	35.2 ± 0.27

*L—lightly thinned
H—heavily thinned

Studies on the cellular components of the various tissues indicate slight detectable differences in cell sizes between the tissues from the two pollen treatments and the differential thinning. Consistent differences in cell sizes could not be detected in the parenchymatous cells which comprise the bulk of the outer pericarp wall, but slight differences in cell length were noted in the tissue of elongated pericarp cells which lie approximately 6 to 10 cells from the seed coat. These differences indicated in Table 1 suggest that heavy thinning in both cases increased slightly the length of the individual cells, hence the length of the fruit.

While the present studies do not indicate conclusively the effect of pollen source on cell number, one could infer from the data that Crane pollen might have induced the development of more cells of lesser, or approximately equal, size to produce the comparatively larger fruits.

A tentative conclusion suggested by these preliminary studies is that fruit thinning increases fruit size through the slightly greater elongation and enlargement of the individual cells. Specific pollens may possibly affect cell number early in fruit development.

LITERATURE CITED

1. *Long, E. M. Developmental anatomy of the fruit of the Deglet Noor date. Bot. Gaz.* 104: 426-436. 1943.
2. *Nixon, R. W. The direct effect of pollen on the fruit of the date palm. Jour. Agric. Res.* 36: 97-128. 1928.
3. *Nixon, R. W. Metaxenia in dates. Proc. Amer. Soc. Hort. Sci.* 32: 221-226. 1934.
4. *Nixon, R. W., and Crawford, C. L. Fruit thinning experiments with Deglet Noor dates. Proc. Amer. Soc. Hort. Sci.* 34: 107-115. 1937.
5. *Swingle, W. T. Hypothetical explanation of metaxenia or effects exerted by the male parent on tissues of the mother plant lying outside of the embryo and endosperm. Abst. Proc. Inter. Congress Pl. Sci., Ithaca, N. Y.* 1926.

EVALUATION OF SOME PHYSICAL METHODS FOR DETERMINING THE MOISTURE CONTENT OF DATES

Frank H. Schiller[1] and V. P. Maier

Fruit and Vegetable Laboratory, Western Utilization Research and Development Division, Agricultural Research Service, United States Department of Agriculture, Pasadena, California

Studies underway at this laboratory on the chemical changes associated with the deterioration of dates during storage and on the development of new and improved dehydrated date products require accurate knowledge of the moisture content of these materials. The importance of moisture on the chemical deterioration (11, 12), microbial spoilage (2, 6), and sugar spotting (9) of fresh dates has been demonstrated previously. Of the moisture methods presently used for dates, the vacuum oven procedure is the most accurate, but very slow. Refractive index (10) and electrical resistance (3, 13) methods are rapid but the former cannot be used on materials having a moisture content below 15 percent and it becomes inaccurate below 20 percent, while the latter is generally not used below 14 percent moisture. Since a rapid moisture method was desired which could be used for both fresh dates and dehydrated date products other methods were investigated.

The Moisture Register[2], a dielectric type instrument, is reported to be rapid and useful over a wide range of moistures (1). While calibration curves (at a pressure of 500 pounds per square inch) for use with dates are available (1) it is necessary to calibrate this instrument under conditions of actual use if the best accuracy is to be obtained. A pressure of 1500 pounds per square inch was used in this study because it eliminated the need for grinding dry date particles to a fine powder in order to obtain a uniformly packed sample. The use of this high pressure, therefore, not only eliminated the difficulty encountered in grinding dry date particles, but also did away with the danger of moisture absorption by this hygroscopic material during sample preparation.

The Moisture Balance[2], an infrared oven-balance type instrument, has never been used, to our knowledge, for determining the moisture content of dates. This method is also rapid and has been reported to be applicable to materials of low moisture content (7).

Accordingly, procedures were developed and evaluated for these two instruments using Deglet Noor hydrated and natural dates and dehydrated date products. Both methods gave results which compared well with those of the standard vacuum oven procedure.

EXPERIMENTAL

Date samples. Fresh whole natural, macerated, extruded and dehydrated Deglet Noor dates were obtained from commercial sources. The moisture content of the whole and macerated dates was adjusted, when necessary, by hydrating in a climatic chamber at 80° F. and 85 percent relative humidity or by dehydrating at 80° F. and 10 percent relative humidity. Extruded dates were dehydrated in a vacuum oven at 158° F. and 75 mm. pressure. Whole dates were pitted and ground twice through the finest cutter of a food chopper prior to use. Macerated, extruded and dehydrated extruded dates were ground in this same manner. The dehydrated date material which varied in particle size from powder to raisin size granules was used without further treatment. In one case dehydrated granules coated with powdered starch were also used. When a series of determinations was being run on the same material it was stored in moisture proof containers at 38° F.

Dielectric Instrument. The determination of moisture content with this instrument is based on the measurement of the radio frequency dielectric properties of the sample. A constant voltage transformer, and a modified hydraulic jack with an automatic hydraulic pump and pressure control device were added[3] to the standard (Model G-5) instrument to insure constant voltage and pressure. Precise control of these two factors was shown by Rockland (8) to be essential for good reproducibility with this instrument. It was found through empirical studies that 1500 pounds pressure gave the best results. Lower pressures were insufficient for uniform packing of dried particles while higher pressures caused leakage of moist samples from the sample cup. Three range boxes (No. 5, 9 and 20) were used for increased accuracy to cover the moisture ranges under investigation. Since temperature has an effect on the results obtained with this instrument all determinations were performed in a room held at 75-80° F. Also, the date samples were always brought to this temperature before use.

In making a determination approximately 50 grams of date material was placed in the sample cup and subjected to a pressure of 1500 pounds per square inch. This pressure was maintained throughout the determination. Before each reading the appropriate range box was first standardized against its calibration standard. The range box was then connected to the instrument and plugged into the electrode holding the sample cup. The meter reading of the sample was taken from the galvanometer scale which had a range of zero to 50. In each case the standardization procedure was repeated until constant readings for the sample were obtained.

Calibration curves, Figure 1, which relate meter reading to moisture content, were established for each range box by means of measurements on numerous date samples whose moisture contents were determined by the vacuum oven method. Table 1 lists the data used in constructing these calibration curves. All subsequent data obtained using this method were converted from dial reading to percent moisture using the calibration curves given in Figure 1.

Infrared Instrument. Moisture analysis with this instrument is based on the removal of water from the sample through the application of heat. A 125-W industrial infrared lamp serves as the heat source. The amount of water removed is determined by measuring the weight loss of the sample with a torsion balance which forms an integral part of the instrument. The balance scale is arranged so that it reads directly in percent moisture. To facilitate the use of different, but constant infrared lamp intensities during the drying process the standard instrument was modified[3] by the addition of a voltmeter, variable transformer and a constant voltage transformer.

Preliminary studies in which the

---

[1] *Employed by Date Administrative Committee under Memorandum of Understanding.*

[2] *The mention of special instruments or materials does not imply endorsement by the Department of Agriculture over others of similar nature.*

[3] *The modified form of this intrument was developed by Dr. L. B. Rockland in his work on moisture determination of shelled walnuts.*

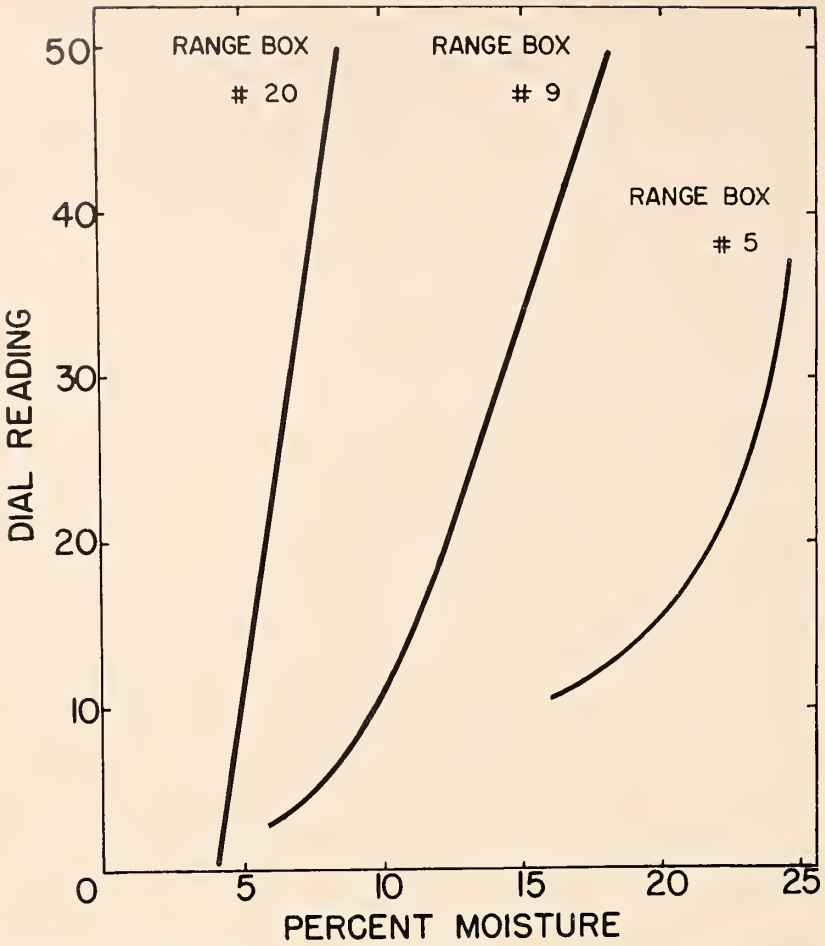

Figure 1—*Calibration curves for the dielectric method of moisture analysis.*

lamp voltage and the time of heating were varied showed that high voltages caused excessive scorching and low voltages were either inadequate or too slow (7). A two-stage procedure was finally adopted which gave the best precision and was still reasonably rapid. In making a determination, sufficient material (5 grams) was evenly distributed over the surface of the pan to bring the dial to zero. The sample was dried for 10 minutes at 85 volts followed immediately by 12 minutes at 95 volts. At the end of this time the moisture content of the sample was read directly from the dial. Strict adherence to this voltage-time schedule was necessary for the attainment of good precision and accuracy with this instrument. The instrument was always allowed to warm up for 15 minutes prior to use.

The moisture contents of various types of date materials determined using this procedure are listed in Table 2 along with the corresponding vacuum oven moisture results.

The reproducibilities of the dielectric (Table 3) and infrared (Table 4) procedures were tested by making 15 separate determinations on each of the following four sample: A) dehydrated granules, B) dehydrated choice natural dates, C) choice natural dates and D) hydrated macerated dates. Samples B, C and D were ground as previously described.

Vacuum oven procedure: A vacuum oven procedure was used as the Standard method of moisture determination. Five gram samples were dried for 20 hours at 158° F. and 75 mm. pressure in a vacuum oven. This drying time was chosen as the result of a study in which the loss in weight of four samples of widely different moisture contents and particle sizes was determined at six hour intervals over a period of 72 hours. The bulk of the weight loss occurred in the first six hours, followed by a loss in weight of 0.5 to 1.5 percent in the subsequent 12 hours. During the remainder of the drying time the weight loss proceeded at a slow constant rate of less than 0.1 percent every six hours, and was probably due to sugar decomposition (3). The reproducibility of this vacuum oven procedure was found to be ± 0.2 percent moisture over the entire moisture range studied. All moistures are reported in terms of percent of wet weight.

In order to check the results of the vacuum oven method the Karl Fisher titrimetric method was tried using dates of both high and low moisture levels. Both methanol (5) and formamide (4) were employed as solvents in conjunction with the application of heat and shaking. However, the results obtained were generally 20 to 30 percent below those of the vacuum oven method. This was probably due to incomplete extraction of the water from the date tissue. Since the development of this procedure was not within the scope of this investigation the method was not studied further.

An estimation of the accuracy (with respect to the vacuum oven method) with which the moisture content of dates can be determined using the two procedures is given in Table 5. Triplicate determinations were made using each of the three methods on each of four samples whose moisture contents ranged from 6 to 22 percent.

RESULTS AND DISCUSSION

The calibration curves for the dielectric method, Figure 1, using three different range boxes cover the moisture range 4 to 24 percent as follows:

Range Box No.	Moisture Range, Percent
20	4— 8
9	6—18
5	17—24

Practically the entire moisture range can be covered using only boxes No. 9 and No. 5, however, it is obvious from the calibration curve that box No. 9 is not very accurate in the 6 to 8 percent range. For this reason box No. 20 is used for this low moisture region. Range box No. 5 is limited to use over the moisture range 17 to 24 percent due to erratic results above and below these limits. The calibration curve obtained using box No. 5 at 1500 pounds pressure compares reasonably well with that reported previously (1) for box No. 5 at 500 pounds pressure. Variations between the two curves are probably due to the different pressures used.

The usefulness of the infrared procedure for determining the moisture content of date material over the moisture range 6 to 24 percent is illustrated by the data in Table 2. When moistures determined by the vacuum oven and infrared procedures were plotted against each other a straight line was obtained which passed through the origin of the graph. This demonstrates that the latter results are directly related to vacuum oven results and, therefore, require no calibration curves or correction factors. This type of relationship was expected since both methods are based on the same prin-

Table 1—Dielectric method calibration curve data.

Sample Deglet Noor Variety	Range box No., 1500 psi pressure	No. of determinations	Dial reading range	Dial reading average	Vacuum oven[1] percent moisture
powder	20	3	9.0— 9.5	9.3	4.9
particles, raisin size	20	15	18.5—24.0	21.2	5.8
particles, raisin size	20	3	22.0—25.0	23.1	6.1
natural-dry	20	2	42.0—43.5	42.7	7.9
particles, raisin size	9	2	3.0— 3.2	3.1	6.1
particles, starch coated	9	2	7.8— 8.0	7.9	9.1
natural, dehydrated extruded	9	5	28.2—31.0	29.5	13.9
natural, extruded	9	3	31.5—35.5	34.0	15.0
natural-dry	9	2	47.0—47.5	47.2	17.4
natural-dry	5	15	12.0—13.1	12.5	17.7
natural	5	3	14.5—15.5	14.7	21.2
natural	5	15	18.5—21.0	19.5	21.8
macerated, hydrated	5	15	30.6—35.9	31.3	24.2

[1]Average of three determinations.

Table 2—Infrared method data compared with the vacuum oven standard.

Sample Deglet Noor variety	No. of determinations	Infrared method, percent moisture range	Infrared method, percent moisture average	Vacuum oven[1] percent moisture
powder	3	5.9— 6.3	6.1	4.9
particles, raisin size	15	5.3— 6.6	5.9	5.8
particles, raisin size	3	5.7— 5.9	5.8	6.1
natural-dry	3	8.1— 8.3	8.2	7.9
particles, starch coated	3	8.6— 9.3	8.9	9.1
natural, dehydrated extruded	3	13.2—14.2	13.7	13.9
natural, extruded	3	14.1—15.0	14.7	15.0
natural, dehydrated extruded	3	15.4—16.7	16.2	15.9
natural, macerated	3	16.5—17.2	16.7	16.8
natural	3	16.1—16.9	16.6	17.4
natural	15	16.9—18.7	17.7	17.7
natural	3	20.3—21.5	20.9	20.9
natural	15	20.7—22.8	22.0	21.8
natural	3	20.8—21.1	21.2	21.9
natural	3	22.6—23.3	23.1	22.6
natural, macerated	3	23.7—24.3	24.0	23.3
natural, macerated	15	23.5—25.2	24.3	24.2
natural, hydrated	3	24.7—25.8	25.3	25.0
natural, hydrated	3	25.8—25.9	25.9	26.4

[1]Average of three determinations.

Table 3—Estimate of the precision of the dielectric method.

Sample[1]	Replicate determinations	Moisture range percent	Moisture average percent	Standard deviation[2], d percent	Coefficient of variation[3] V percent	Vacuum oven[4] moisture percent
A	15	5.7— 6.2	6.0	0.2	2.7	5.8
B	15	17.4—18.4	17.8	0.3	1.5	17.7
C	15	21.5—22.3	21.8	0.3	1.2	21.8
D	15	24.1—24.7	24.4	0.2	0.7	24.2

[1]See text

[2]$d = \sqrt{\frac{\Sigma\, d^2}{N-1}}$

[3]$V = \frac{100d}{\text{mean}}$

[4]Average of three determinations.

Table 4—Estimate of the precision of the infrared method.

Sample[1]	Replicate determinations	Moisture range percent	Moisture average percent	Standard deviation[2], d percent	Coefficient of variation[3] V percent	Vacuum oven[4] moisture percent
A	15	5.3— 6.6	5.9	0.1	1.9	5.8
B	15	16.9—18.7	17.7	0.2	0.9	17.7
C	15	20.7—22.8	22.0	0.2	1.1	21.8
D	15	23.5—25.2	24.3	0.5	2.1	24.2

[1]See text

[2]$d = \sqrt{\frac{\Sigma\, d^2}{N-1}}$

[3]$V = \frac{100d}{\text{mean}}$

[4]Average of three determinations.

ciple, namely decrease in weight due to moisture loss. Table 2 also lists the wide variety of date materials to which this method has been applied.

An estimate of the reproducibilities of the two methods under test is given in Tables 3 and 4. The standard deviation, which is a statistical estimation of reproducibility, is relatively constant over the entire moisture range in the case of the dielectric method. With the infrared method, however, the standard deviation becomes larger as the moisture content increases. However, except for the high moisture region both methods have comparable reproducibilities.

A test of the accuracies of the two procedures using the vacuum oven method as a standard is given in Table 5. In the case of the dielectric method the averages of triplicate determinations deviate from the standard by approximately± 0.5 percent moisture. When single determinations are considered the deviation is in the region of about ± 1 percent moisture. With the infrared method the data in Table 5 and also Table 2 show that the deviation when the averages of triplicate determinations are used is about ± 0.5 percent moisture. The deviation from the standard of single determinations is approximately ± 1 percent moisture. Thus, the two methods have similar accuracies over the moisture range studied.

In conclusion, the two procedures developed were found to be applicable to a wide variety of Deglet Noor date materials, including hydrated (whole and macerated), natural (whole, extruded, and macerated) and dehydrated (extruded, granular, and powdered) dates over the moisture range 4 to 24 percent. It should be emphasized that 4 to 24 percent moisture is not the limit of usefulness of these instruments, but simply the range covered in this study. It should be possible to extend this moisture range if so desired. The accuracies of the two methods are comparable over the moisture range mentioned and are estimated to be ± 0.5 percent moisture when the average of triplicate determinations is used and ± 1 percent moisture with single determinations. Determinations with the dielectric method (5 minutes per determination) are somewhat faster than those with the infrared method (25 minutes per determination) but require the use of calibration curves. These methods should be useful for industrial as well as research purposes, but in either case they should be standardized under the conditions of actual use against material of known moisture content in order to give reliable results.

Table 5—Comparison of the infrared and dielectric procedures with the standard vacuum oven method for determining the moisture content of dates.

Sample Deglet Noor variety	Vacuum oven[1], percent moisture range	average	Infrared method[1], percent moisture range	average	Dielectric method[1], percent moisture range	average
particles, large raisin size	6.4- 6.6	6.5	5.3- 6.6	5.9	6.0- 6.2	6.1
natural, dehydrated extruded	13.7-14.2	13.9	12.8-13.6	13.2	14.4-15.1	14.6
natural, extruded	17.1-17.2	17.1	16.5-16.9	16.7	17.0-18.0	17.4
natural	22.4-22.6	22.5	22.3-22.7	22.5	21.9-22.1	22.0

[1]Three determinations.

SUMMARY

Methods have been developed for the rapid moisture determination of Deglet Noor dates over the moisture range 4 to 24 percent using a dielectric instrument and an infrared oven-balance instrument. Standard deviations of both methods were calculated. Calibration curves for 3 different range boxes for the dielectric instrument were drawn. All results were compared with the vacuum oven method.

Acknowledgments:

The authors acknowledge with gratitude the helpful suggestions of Dr. L. B. Rockland. The dates employed in the present study were supplied through the courtesy of B. J. Peightal, Date Administrative Committee, Indio, California.

LITERATURE CITED

1. *Anonymous.* 1955. *The G-5 Moisture Register. Moisture Register Company Circular. Alhambra, California.*
2. *Cleveland, H. H. and Fellers, C. R.* 1932. *The Mineral Composition of Dates. Ind. Eng. Chem., Anal. Ed.* 4: 267-268.
3. *Joslyn, M. A.* 1950. *Methods in Food Analysis. Academic Press, Inc., Publishers. New York.*
4. *McComb, E. A. and McCready, R. M.* 1952. *Rapid Determination of Moisture in Dehydrated Vegetables with Karl Fisher Reagent by use of Formamide as an Extraction Solvent. J. Assoc. Offc. Agr. Chem.* 35: 437-441.
5. *Mitchell, Jr., J. and Smith, D. M.* 1948. *Aquametry. Interscience Publishers, Inc. New York.*
6. *Nielsen, B. W., McColloch, R. J. and Beavens, E. A.* 1950. *Processing and Packaging of Dates. I. A New Method of Pasteurizing Deglet Noor Dates. Food. Tech.* 4: 232-237.
7. *Rockland, L. B.* 1957. *A New Treatment of Hygroscopic Equilibria: Application to Walnuts (Juglans regia) and Other Foods. Food Research,* 22: 604-628.
8. *Rockland, L. B. Unpublished data.*
9. *Rygg, G. L.* 1942. *Factors Affecting Sugar Spotting in Dates. Date Growers' Inst. Ann. Rept.* 19: 10-12.
10. *Rygg, G. L.* 1945. *Determination of Moisture in Dates by Means of a Refractometer. Date Growers' Inst. Ann. Rept.* 22: 3-4.
11. *Rygg, G. L.* 1956. *Effect of Temperature and Moisture Content on the Rate of Deterioration in Deglet Noor Dates. Date Growers' Inst. Ann. Rept.* 33: 8-11.
12. *Rygg, G. L.* 1957. *The Relation of Moisture Content to Rate of Darkening in Deglet Noor Dates. Date Growers' Inst. Ann. Repi.* 34: 12-13.
13. *Stadtman, E. R., Barker, H. A., Mrak, E. M. and Mackinney, G.* 1946. *Storage of Dried Fruit; Influence of Moisture and Sulfur Dioxide on Deterioration of Apricots. Ind. Eng. Chem.* 38: 99-104.

THE INFLUENCE OF HEAVY IRRIGATION AND FERTILIZATION ON GROWTH, YIELD AND FRUIT QUALITY OF DEGLET NOOR DATES

J. R. Furr and W. W. Armstrong, Jr.

Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture
Date Field Station, Indio, California

The quality of fruit produced on Deglet Noor palms in the Coachella Valley has been generally supposed to depend to a considerable extent on the cultural practices followed. Some growers have considered that copious irrigation and liberal fertilization with manure and other nitrogenous fertilizers are conducive to heavy yields of fruit of high quality. The writers have observed several plantings on deep sandy soils and one on a sandy loam in which these practices have apparently produced both yields and quality of fruit above the general average of the Coachella Valley.

It is well known, however, that the variety Deglet Noor is not so well suited to relatively heavy soil types (sandy loams to clay loams) as are such varieties as Halawy, Zahidi and Khadrawy. There is some question whether even very liberal applications of water and fertilizer and good care in other respects will induce heavy yields of fruit of high quality by Deglet Noor palms on some of the heavy soils that are for the most part considered to be entirely satisfactory for other date varieties.

A block of Deglet Noor palms planted about 1941 on Indio very fine sandy loam at the U. S. Date Field Station has a long history of producing fruit of low quality, although this soil type in some other locations produces Deglet Noor fruit of good quality. This soil is underlain by sand at a depth of 4 or 5 feet, does not have a water table within 40 feet of the soil surface and is well drained.

An experiment with this block of Deglet Noor trees was begun in April 1954 to see what influence wide variations in water and nutrient supply would have on growth of trees and on yield and quality of fruit. Since these trees had received no fertilizer for 9 years prior to this test and were therefore probably suffering nutrient deficiency, they seemed to be well suited for testing the influence on nutrient supply on young palms that had just reached the age of full bearing.

MATERIALS AND METHODS

The block was too small to accommodate a plot lay-out of replicated treatments and was consequently divided into 3 different irrigation plots with one border row between plots. Statistical analysis of the results obtained from these plots was, of course, not possible. Water from the Coachella Valley Branch of the All American Canal was applied to each plot at a different rate as follows: "High" (H), 14 feet per year; "Medium" (M), 10 feet per year; and "Low" (L), 6 feet per year. The one half of each irrigation plot was unfertilized (—N) and the other half was heavily fertilized (+N) with manure and inorganic nitrogen as follows: 1954, 9 tons of steer manure

Table 1—The influence of variations in water and nitrogen supply on growth, bunch production, yield, size and grade of fruit of Deglet Noor dates.

Year and treatment[1]	Av. trunk height gain feet	Leaf growth index[2]	Av. mature bunches per tree number	Av. yield per tree pounds	Percent crop in grades above sub-std. Natural	Semi-dry	Standard dry	Av. weight per fruit grams
1954:								
+N	1.9	109	11.8	174	29	45	16	.....
—N	1.5	91	11.7	181	23	52	15	.....
H	1.7	101	11.8	185	30	45	17	.....
M	1.9	105	12.1	178	28	52	13	.....
L	1.5	96	11.0	170	22	49	16	.....
1955:								
+N	2.2	114	16.3	280	33	28	28	.....
—N	1.4	89	14.0	258	16	34	41	.....
H	1.8	99	15.5	258	18	29	39	.....
M	2.1	108	14.9	265	35	33	23	.....
L	1.5	97	15.0	284	22	30	39	.....
1956:								
+N	2.1	109	16.6	282	11	....	77[3]	10.7
—N	1.2	87	12.6	221	6	....	78	10.8
H	1.7	97	16.1	274	6	....	78	10.8
M	1.7	103	13.4	240	12	—	75	11.0
L	1.4	96	14.0	241	7	....	79	11.4
1957:								
+N	1.2	111	16.5	242	33	36	23	10.4
—N	1.0	89	12.4	193	34	44	15	11.8
H	0.8	99	14.6	260	31	44	20	11.3
M	1.4	105	13.8	205	38	37	15	11.1
L	1.2	96	13.3	188	29	37	24	10.9

[1]Treatments: +N Nitrogen fertilizers applied
—N Not fertilized
H 14 feet water applied per year
M 10 feet water applied per year
L 6 feet water applied per year

[2]Leaf-growth index: 1954, av. growth rate of all trees=100
1955-1957, 3-yr. av. growth rate of all trees=100

[3]Standard dry and semi-dry combined in 1956.

per acre and 3 pounds of inorganic nitrogen per tree; 1955, 8 tons of manure per acre and 3 pounds of inorganic nitrogen per tree; in 1956, 19.6 tons of manure per acre and 1 pound of inorganic nitrogen per tree. The manure contained about 1.5 percent nitrogen, so that about 8 to 13 pounds of nitrogen per tree per year was applied. In 1957 fertilizer was not applied until after harvest in late November and of course did not influence the 1957 crop.

There were 4 record trees in each half of the H and M plots and 2 record trees in each half of the L plot. For much of the year water was applied at approximately weekly intervals to the H plot, about every 2 weeks to the M plot and about every 3 weeks to the L plot; but modification of this schedule was necessary in fall and winter to bring the total yearly applications to 14, 10 and 6 acre feet per acre on the H, M and L plots, respectively.

In addition to yield and grade records of fruit produced by the trees of each plot, records were kept of annual gain in height of the tree trunks and of growth rate of the young leaves on each test tree at frequent intervals. The inflorescences produced and the number allowed to mature fruit on each tree each season were counted; and in 1956 and 1957 samples of 200 fruit per tree at each pick were weighed as a measure of average fruit size.

RESULTS

The results obtained in 4 years of differential irrigation treatment (Table 1) show such small and erratic differences between treatments (H, M, L) in growth of trunk and leaves, in production of bunches and in yield, grade and size of fruit that it is apparent that the differences in water supply to these palms had little influence on them.

At the start of this experiment, in April 1954, the average height of trunk of unfertilized and fertilized trees was practically the same; thus it appears that up to that time the average rate of growth of the two lots of trees was about the same. Since growth rate of trunk is closely related to growth rate of leaves in date palms, it is also likely that the average growth rate of leaves of the unfertilized and the fertilized trees was about the same before the fertilizer treatment was started.

Apparently the rates of leaf growth and trunk growth were increased, even in 1954, as a result of the application of nitrogenous fertilizers (Table 1). During the remaining 3 years of the experiment the growth rates of trunks and leaves, the production of fruit bunches, and the yields of fruit of the fertilized trees were greater than those of unfertilized trees.

The influence of nitrogen fertilization on quality or grade of fruit was much less pronounced than on growth of trees or yield of fruit. During the first 3 years of treatment the quality of the fruit produced by both fertilized and unfertilized trees was so poor that the slight differences observed seem to be of little importance, though the percentages of naturals were higher on the fertilized than on the unfertilized trees. In 1956, because of abnormally high temperatures in September, the fruit ripened so rapidly that it was nearly all dry when harvested, and therefore the small amount of semi-dry fruit was included in the standard-dry grade.

In 1957 the average yield of the fertilized trees was considerably greater than that of the unfertilized trees. This difference in crop load resulted in smaller fruit on the fertilized than on the unfertilized trees. The percentage of naturals was about the same under both treatments, but it appears that fertilization resulted in a decrease in the percentage of semi-drys and an increase in the percentage of standard drys. Though the quality of fruit from neither the fertilized nor the unfertilized trees was very good, the grade-out data fail to indicate the rather striking difference in appearance of the fruit from the fertilized and the unfertilized trees. Fruit from the fertilized trees was distinctly less attractive in color than that from the unfertilized trees. Much of the fruit in the natural grade from the fertilized trees was "off-color," that is, reddish, greenish or light grayish brown or affected with blacknose and dark in color. Some of it was also somewhat "rubbery" (8) in texture. In the dry grades from the fertilized trees there was a large amount of reddish fruit, and much of it was the very red, small, shriveled acid type (8) that does not hydrate properly.

DISCUSSION AND CONCLUSION

Since it had been found that about 5 feet per year (2) was the consumptive use of water by Khadrawy palms on a soil similar to that in this experiment, it seems likely that 6 feet of water per year on the L plot was barely enough to supply the trees and prevent a harmful accumulation of salt. In the summer the top 4 feet of soil dried out so much between irrigations that the soil was usually not rewetted to 4 feet by the later summer applications of water and, of course, during this period salts were accumulating. The water applied during winter and spring presumably lowered the salt concentration below an injurious level. Even though the trees in the L plot showed no obvious harmful effects after 4 years of treatment, 6 feet of water per year would probably not be

enough on most soils to supply mature date palms with adequate amounts and, in addition, to prevent salt accumulation.

The response to nitrogen fertilization by the date palms in this experiment was quicker and more pronounced than in previously reported fertilizer trials with dates in the Coachella Valley of California (3).

The rapid response observed doubtless occurred because the trials were begun after the nitrogen reserves of the soil had been depleted by 9 years of clean cultivation without any fertilization or growth of legume cover crops. As a result of the slow response to nitrogen fertilization in some other trials (4), (5) we had supposed that perhaps several years are required after nitrogen fertilization to bring about the increase in leaf surface and in number of inflorescences necessary to produce an appreciable increase in yield of dates. The results of this experiment indicate, however, that if trees are sufficiently deficient in nitrogen they will respond to fertilization in the spring by an increased rate of leaf growth during that same season and by increased inflorescence production in the spring of the following year.

The chief object of this experiment was to find out whether the quality of fruit produced by these trees with a previous history of producing fruit of low quality could be materially improved by liberal applications of water and nitrogenous fertilizers. The results show that the treatments had little influence on grades during the first three years of the test. The quality of fruit was very poor regardless of treatment. In these years weather conditions were unfavorable for the production of fruit of high quality, but in 1957, when weather conditions were favorable, the fruit produced on the fertilized trees was distinctly lower in quality than that produced on the unfertilized trees. This lowering of quality was almost certainly the result of excessive nitrogen fertilization. In 1956 about 13 pounds of nitrogen per tree was applied, and it is likely that half of this amount would have been adequate for maximum growth and yield. Ill effects on fruit quality of excessive nitrogen fertilization of apples (1), peaches (7), citrus (6) and other fruits have been reported. The production of fruit of small size, the darkening of fruit, and the development of an unattractive greenish color in fully ripe fruit on trees fertilized with 8 pounds of inorganic nitrogen per year were reported in a previous experiment with Deglet Noor dates (5). At that time it was not fully realized that these defects in fruit quality resulted from excessive nitrogen fertilization. The lowering of quality that resulted from 8 pounds of inorganic nitrogen per tree also indicates that in the present experiment it was the nitrogen rather than other nutrients contributed by the manure that was responsible for the lowering of quality.

Though excessive amounts of nitrogen should not be used, because of both the ill effects on fruit quality and the needless expense, it is clear from the results of this experiment and others (3) that with no fertilization the nitrogen reserves of Coachella Valley soils are lowered in a few years to the point where nitrogen must be applied to maintain high yields.

It is possible that in this test two factors contributed to the poor quality of the fruit produced by the fertilized trees: excessive nitrogen and overloading of the trees. A test has been started on similar soil with Deglet Noor trees just coming into full bearing to see what effect varying the crop load will have on quality of fruit from trees that are given adequate but not greatly excessive amounts of water and nitrogen.

SUMMARY

In a 4-year trial with Deglet Noor dates on a very fine sandy loam soil that had not been fertilized for 9 years and that had for many years produced fruit of low quality, water was applied to different plots at rates of 6, 10 or 14 feet per year. On a half of each of these plots about 8 to 13 pounds of nitrogen from manure and inorganic fertilizer was applied annually per tree for the first 3 years. The object of the experiment was to determine the effects of these treatments on growth, on yield, and especially on fruit quality.

The variations in water supply had little measurable effect on growth of trees or on yields or grades of fruit. In response to nitrogen fertilization, however, there was a marked improvement in growth of leaves and trunks in the first year of treatment as well as an increase in inflorescence production and yields in the second year. From the results of other fertilization tests it was supposed that several years may be required for palms to show a yield increase in response to nitrogen; but this experiment shows that if growth and yields are seriously limited by nitrogen shortage, dates may show a yield increase within a year after fertilization.

During the first 3 years of the test weather was not favorable for the production of fruit of high quality, and though nitrogen fertilization apparently caused a slight increase in naturals, fruit quality was low regardless of treatment.

In 1957, the 4th year of treatment, the weather was favorable for production of fruit of high quality; but the fruit from none of the plots was of high quality and the fruit from the fertilized trees was of lower quality and smaller size than that from unfertilized trees.

Much of the fruit from fertilized trees had poor color (greenish, grayish, reddish or dark) and poor texture. This lowering of quality of fruit on fertilized trees apparently resulted from the application of excessive amounts of nitrogen. With half the amount of nitrogen applied to the fertilized trees maximum yields would probably have been attained without lowering fruit quality.

LITERATURE CITED

1. *Boynton, D.* 1954. *Apple nutrition. Ch.* 1, *pp.* 1-78 *in "Fruit Nutrition," edited by N. F. Childers, New Brunswick, N. J.*

2. *Furr, J. R. and W. W. Armstrong.* 1956. *The seasonal use of water by Khadrawy date palms. Date Growers' Inst. Rept.* 33: 5-7.

3. *Furr, J. R. and W. W. Armstrong, Jr.* 1957. *Nitrogen fertilization of dates—a review and progress report. Date Growers' Inst. Rept.* 34: 6-9.

4. *Furr, J. R., E. C. Currlin and W. W. Armstrong.* 1952. *Effects of water shortage during ripening and of nitrogen fertilization on yield and quality of Khadrawy dates. Date Growers' Inst. Rept.* 29: 10-12.

5. *Furr, J. R., E. C. Currlin, R. H. Hilgeman and W. Reuther.* 1951. *An irrigation and fertilization experiment with Deglet Noor dates. Date Growers' Inst. Rept.* 28: 17-20.

6. *Jones, W. W., T. W. Embleton and M. L. Steinacker.* 1957. *Nitrogen fertilizers as related to orange quality and yield. Calif. Citrograph* 43: 3, 12.

7. *Proebsting, E. L.* 1958. *Fertilizers and covercrops for California orchards. Calif. Agr. Exp. Sta. Ext. Ser. Cir.* 466.

8. *Rygg, G. L.* 1948. *Acidity in relation to quality in the date fruit. Date Growers' Inst. Rept.* 25: 32-33.

Date Growers' Institute - 1958 Membership

(As of September 12, 1958)

Al-Delaimy, Khalef . . . . . Bagdad, Iraq
Arkell Date Gardens . . . . . Indio
Asker, Earl . . . . . Indio

Benninghoff, Howard . . . . . Thermal
Blackburn, R. W. . . . . Thermal
Breyer, Alberto . . Buenos Aires, Argentina
Brown, Thomas R. . . . . Thermal
Burnham, Roderick . . . . . Palm Springs

California Date Growers' Ass'n . . . Indio
Carlson, Ted
Carreon, Dr. R. J., Jr. . . . . Indio
Cast, Edna—Garden of Setting Sun . . Mecca
Cavanagh, H. L. . . . . Palm Desert
Citrus Experiment Station—U. of C. Riverside
Coachella Valley Publishing Co. . . . Indio
Codekas, Jerry . . . . . Thermal
Cook, Robert E. . . . . Indio
Cook, W. W. . . . . Palm Desert
Cosgrove, Robert S. . . . . Indio
Crommelin, Mrs. J. B. . . . . Palm Springs
Cruess, W. V. . . . . Berkeley

Darley, E. F. . . . . Riverside
Darnell, Mrs. W. G. . . . . Brawley
Dates Officer . . . Berbera, Somaliland Pro.
Dillman, R. S. . . . . Winter Haven
Downing, A. P. . . . . Brewton, Alabama

Echols Ranch . . . . . Thermal
El Fawal, Ahmed Nagiub . Damarhoor, Egypt
Embleton, Tom W. . . . . Riverside

Falk, Rosalie . Lac du Flambeau, Wisconsin
Farrar E. Keith . . . . . Indio
Furr, J. R. . . . . Indio

Grandra, Sidney Orlando . Sao Paulo, Brazil

Heiny, George . . . . . Brawley
Hopland, A. N. (Jim) . . . . . Thermal
Hughes, Larry . . . . . Los Angeles

Jarvis, Eugene . . . . . Thermal
Jenkins, Paul . . . . . Indio
Jenkins, W. G. . . . . Indio

Kral, Louis . . . . . Calexico

Laflin, Ben, Jr. . . . . Thermal
Laflin, Ben, Sr. . . . . Thermal
Leach, George . . . . . Thermal
Leikind, H. . . . . Washington, D.C.
Lichty, Kenneth . . . . . Indio
Lindgren, D. L. . . . . Riverside
Lippincott, Gardner . . . . . Palm Desert

Martin of California . . . . . Los Angeles
Martin, Martha Reid . . . . Rancho Mirage
Macpherson, D. F. . . . . Indio
McCurdy, Mrs. Ralph B. . . . . Pasadena
McCurdy, R. C. . . . . New York
McKay, Arthur L. . . . . Indio
Mitchell, D. H. . . . . Indio
Mock, D. C. . . . . Redlands
Moshe, Zait . . . . . Beit-Shaw, Israel
Mrak, Emil M. . . . . Davis

Nittinger, Robert E. . . . . Santa Monica
Nixon, Roy W. . . . . Indio
Noland, Warren . . . . . Los Angeles

Patterson, Kenneth . . . . . Coachella
Peightal, B. J. . . . . Indio
Pinyon, R. A. . . . . Indio
Pryor, Mrs. Anna T. . . . . Los Angeles
Puls, J. H. . . . . Pasadena

Reid, Robert H. . . . . Chicago
Reuther, Walter . . . . . Riverside
Richardson, H. B. . . . . Davis
Riverside Co. Agri. Com. . . . . Riverside
Robertson, Marie . . . . . San Diego
R R J Ranch . . . . . Indio
Russel, Robbins . . . . . Redlands
Rygg, G. L. . . . . Pomona

Scheniman Paper Co. (E. E. Cousins) . Indio
Schroeder, C. A. . . . . Los Angeles
Shields, Floyd . . . . . Indio
Smead, Paul F. . . . . Thermal
Steoning, Donald A. (Coachella Ranches)
. . . . . Riverside
Sunipalms Date Gardens (Christian E. L.)
. . . . . Indio
Swingle, Leonhardt . . . . . Indio
Swingle, Mrs. Walter T. . . . San Francisco

Turk, Howard . . . . . Coachella

Venus Foods . . . . . Los Angeles
Vincent, Lloyd . . . . . Riverside

Walker, Dr. Joseph . . . . . Hollywood
Wallace, Earl . . . . . Thermal
Webb, Robert . . . . . Palm Desert
Westerfield, John . . . . . Coachella
Western Province Fruit Research Station
. . . . . Stellenbosch, South Africa
Wilson, Gwynn . . . . . Los Angeles
Wise, George . . . . . Mecca

Yowell, Hillman . . . . . Indio

DESERT MAGAZINE PRESS